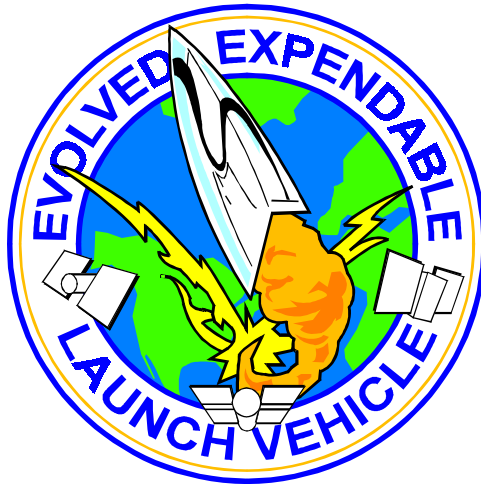


Evolved Expendable Launch Vehicle Standard Interface Specification

Version 6.0

5 September 2000



EELV Standard Interface Working Group
Randy Kendall, Editor

This document was produced and is maintained by the Evolved Expendable Launch Vehicle Program Office in conjunction with The Aerospace Corporation. The material in this document was developed largely from information supplied from the two EELV contractors: Lockheed Martin Astronautics and The Boeing Company, with input from the payload programs at the United States Air Force's Space and Missile Systems Center. Please direct any comments or questions to the POCs below:

SMC POC

Lt. Col Roger Odle
EELV Payload Integration Chief
SMC/MVS
2420 Vela Way, suite 1467/A-2
Los Angeles AFB
El Segundo, CA 90245-4659

Phone: (310) 336-4611
Fax: (310) 336-4350
E-Mail: roger.c.odle@losangeles.af.mil

Editor

Randy Kendall
EELV Mission Integration
The Aerospace Corporation
PO Box 92957 (M/S: M1-131)
Los Angeles, CA 90009-2957

Phone: (310)-336-5553
Fax: (310)-336-2468
E-Mail: randy.kendall@aero.org

TABLE OF CONTENTS

1. INTRODUCTION.....	1
1.1 Purpose	1
1.2 Scope.....	1
1.3 Design Approach	1
1.4 Exclusions.....	2
1.5 Definitions	2
1.6 Acronym List	6
1.7 Reference Documents	9
2. MISSION REQUIREMENTS.....	10
2.1 Orbit Requirements.....	10
2.1.1 Throw Weight	10
2.1.2 Orbit Insertion and Accuracy.....	10
2.1.3 Launch Window	10
2.1.4 Attitude Rates and Accuracies	10
2.1.5 Separation Requirements	10
2.1.5.1 Separation Mechanism.....	10
2.1.5.2 Separation Velocity	11
2.1.5.3 Separation Inhibits	11
2.1.5.4 Separation Contingencies	11
2.1.5.5 Contamination and Collision Avoidance Maneuvers	11
3. PHYSICAL INTERFACES.....	12
3.1 Mechanical Interfaces	12
3.1.1 Interface Definitions	12
3.1.2 Mating Surface.....	14
3.1.2.1 Bolt Pattern	14
3.1.2.2 Flatness	15
3.1.2.3 Master Gauge.....	16
3.1.3 Payload Dynamic Envelopes.....	16
3.1.4 PLF Access Doors.....	19
3.1.4.1 Routine Access	19
3.1.4.2 Emergency Access	19
3.1.5 Payload Adapters	20
3.1.6 Payload Mass Properties	20
3.1.6.1 Center of Gravity Location.....	20
3.1.6.2 Payload Mass Properties.....	21
3.1.7 Payload Stiffness	22
3.2 Electrical/Avionics Interfaces.....	23
3.2.1 Electrical Connections at LV/Payload Interface.....	23
3.2.2 Electrical Connections at EGSE Room.....	23
3.2.3 Payload Electrical Connector Separation.....	25
3.2.4 Ground Interfaces.....	25
3.2.4.1 Ground Power	25
3.2.4.2 Power Leads and Returns	25
3.2.4.3 Power Isolation	26
3.2.4.4 Ascent Power	26
3.2.4.5 Ground Support Equipment Power.....	26

3.2.4.6	Ground Monitoring.....	26
3.2.5	Flight Command and Telemetry Interfaces.....	27
3.2.5.1	Signal Reference.....	27
3.2.5.2	LV to PL Commands	27
3.2.5.2.1	Discrete Commands	27
3.2.5.2.2	Switch Closure Functions	27
3.2.5.3	LV/PL Telemetry Interface.....	28
3.2.5.4	SV Radio Frequency Links.....	28
3.2.5.5	State Vector Data.....	28
3.2.6	Electromagnetic Compatibility	28
3.2.6.1	Radiated Emissions.....	29
3.2.6.1.1	SV Radiation Narrowband.....	29
3.2.6.1.2	SV Radiation Broadband	30
3.2.6.1.3	LV Radiation Narrowband.....	31
3.2.6.1.4	LV Radiation Broadband	32
3.2.6.1.5	Broadband Radiated Emissions Due to Electrostatic Discharge	33
3.2.6.1.6	PLF Electrostatic Discharge	33
3.2.6.1.7	PLF Broadband E-Field Limits	34
3.2.6.2	Electromagnetic Interference Safety Margin (EMISM)	34
3.2.6.3	Range Compatibility	35
3.2.7	Grounding, Bonding, and Referencing	35
3.2.7.1	Electrical Bonding	35
3.2.7.2	Interface Connector Bonding.....	35
3.2.7.3	Chassis Ground Current.....	35
3.2.7.4	PLF Acoustic and Thermal Blanket Layer Interconnection	35
3.2.7.5	PLF Acoustic and Thermal Blanket Grounding	35
3.2.8	Separation Ordnance, Power, and Circuits	36
3.2.8.1	Separation Indication	37
3.3	Fluid Interfaces and Services.....	37
3.3.1	Coolant.....	38
3.3.2	Air Conditioning	38
3.3.2.1	Payload Compartment Air Characteristics and Flow	38
3.3.2.1.1	Transport and Hoist.....	38
3.3.2.1.2	Air Flow Following Payload Mate to the LV	39
3.3.3	SV Instrument Purge (GN ₂)	40
3.3.4	GHe	40
3.4	Thermal Environments	41
3.4.1	Payload Compartment Thermal Environment.....	41
3.4.2	Free Molecular Heating	41
3.5	Contamination Control	42
3.5.1	Cleanliness	42
3.5.2	Impingement.....	42
3.5.3	Windborne Contamination.....	42
3.5.4	Flight Contamination	42
3.5.4.1	Particulate	42
3.5.4.2	Molecular.....	42
3.5.5	Material Selection	42
3.5.5.1	Non-Metallic Materials.....	42
3.5.5.2	Metallic Materials.....	43
3.6	Acceleration Load Factors.....	44
3.7	Vibration	46

EELV - Standard Interface Specification – Version 6.0

3.8	Acoustics.....	46
3.9	Shock	49
3.10	Ground Processing Load Factors	51
3.11	Payload Fairing Internal Pressure.....	51
4.	FACILITIES AND PROCESSING	52
4.1	Propellant Services	52
4.2	Access to Payloads - Timelines	52
4.3	Payload Battery Charging	52
4.3.1	Full Power Charging	52
4.3.2	Trickle Charging	52
4.4	Hazardous Payload Processing	52
4.5	Detanking	52
4.6	Lightning Protection	53

LIST OF FIGURES

FIGURE 1 - EELV STANDARD INTERFACE COORDINATE SYSTEM	12
FIGURE 2 - STANDARD INTERFACE PLANE - RELATIONSHIP TO LV AND PAYLOAD.....	13
FIGURE 3 - SMALL DIAMETER (62.010") PAYLOAD INTERFACE	14
FIGURE 4 - LARGE DIAMETER (173") PAYLOAD INTERFACE	15
FIGURE 5 - EELV STANDARD INTERFACE FLATNESS REQUIREMENT	15
FIGURE 6 - EELV HPC DYNAMIC ENVELOPE	16
FIGURE 7 - EELV 5M IPC DYNAMIC ENVELOPE.....	17
FIGURE 8 – EELV MPC AND 4M IPC DYNAMIC ENVELOPE	18
FIGURE 9 – EELV SMALLER (OPTIONAL) MPC-S DYNAMIC ENVELOPE	19
FIGURE 10 - ALLOWABLE CG LOCATION USING STANDARD PL ATTACHMENT HARDWARE.....	20
FIGURE 11- INTERFACE WIRING HARNESS CONNECTIONS.....	24
FIGURE 12 - MAXIMUM ALLOWABLE NARROWBAND SV RADIATED E-FIELDS	29
FIGURE 13 - MAXIMUM ALLOWABLE BROADBAND SV RADIATED E-FIELDS	30
FIGURE 14- MAXIMUM ALLOWABLE NARROWBAND LV RADIATED E-FIELDS.....	31
FIGURE 15- MAXIMUM LV RADIATED BROADBAND EMISSIONS	32
FIGURE 16- MAXIMUM ALLOWABLE BROADBAND RADIATED E-FIELDS (ESD SOURCE)	33
FIGURE 17 - E-FIELD STRENGTH DERIVED RADially 1 CM FROM PLF INNER SURFACE	34
FIGURE 18 - ORDNANCE TIMING	37
FIGURE 19 - MAXIMUM PLF INNER SURFACE TEMPERATURES.....	41
FIGURE 20 - MPC-S QUASI-STATIC LOAD FACTORS	44
FIGURE 21 – 4M IPC AND MPC QUASI-STATIC LOAD FACTORS	45
FIGURE 22 - 5M IPC AND HPC QUASI-STATIC LOAD FACTORS.....	46
FIGURE 23 – MPC ACOUSTIC LEVELS.....	48
FIGURE 24 – 4M IPC ACOUSTIC LEVELS	48
FIGURE 25 – 5M IPC/HPC ACOUSTIC LEVELS	49
FIGURE 26- EELV MAXIMUM SHOCK LEVELS	50

LIST OF TABLES

TABLE 1 - PAYLOAD MASS PROPERTIES.....	22
TABLE 2 - PAYLOAD STIFFNESS RECOMMENDED FUNDAMENTAL FREQUENCIES.....	23
TABLE 3 - PL MAXIMUM ACOUSTIC LEVELS	47
TABLE 4 - EELV MAXIMUM SHOCK LEVELS	50

1. INTRODUCTION

1.1 Purpose

This document defines the Standard Interface (SI) between the payload (PL) and the Evolved Expendable Launch Vehicle (EELV) system. The SI was developed to standardize equipment, processes and services among systems and vehicles and to standardize payload integration.

This document was developed by the EELV System Program Office (SPO), in collaboration with the two competing EELV contractors, with government representatives, and with representatives of the payload community in the Standard Interface Working Group (SIWG).

1.2 Scope

The Standard Interface Specification (SIS) covers those items provided as a standard service to all payloads and is intended to provide guidance for the design of new payloads. Additional payload requirements will be accommodated using concept-specific or mission-unique hardware, processes, or services as specified in the LV/PL ICD (Mission Specification). The LV/PL ICD is developed by the LVC with input from the SVC and/or LSIC during the launch service period.

Where possible, a common interface characteristic has been defined. However, differences in configurations of the EELV system necessitate different interface specifications at times, particularly in the area of payload size and environments. In these cases, the interface specification is shown separately for each payload class.

1.3 Design Approach

The information provided in this document was developed with two goals in mind:

1. Reducing the cost of launching payloads.
2. Providing users with a capability as good as, or better than, previous launch vehicles.

Therefore, the EELV SIWG philosophy is to provide an equivalent (or better) performance and payload accommodation capability while, at the same time, ensuring that the payload environments are equivalent to (or less severe than) those of the launch vehicles (LVs) previously used to launch military payloads. This “no worse than” policy includes the Delta and Atlas LVs for the heritage Medium Payload Class (MPC) and the Titan IV LV for the heritage Heavy Payload Class (HPC). The accommodations provided by other launch vehicles were considered and taken into account wherever possible. The needs of commercial SV busses were also considered in recognition that military payloads may use commercial busses in the future and that commercial viability is important to the overall cost reduction goal.

The requirements are presented in this document in a singular, independent fashion. It is not the intent of the SIS to impose the most restrictive limit of all requirements simultaneously when this is not a reasonable representation for a payload or mission. Those responsible for the integration of new design payloads should maintain open communication with the EELV Program Office to

take advantage of available concept-specific requirement trades. The requirements that apply to a particular mission will be documented in the negotiated LV/PL ICD.

The SIWG believes that the goals have been accomplished to the greatest extent possible, consistent with the cost reduction goals; the SIWG welcomes user comments on the contents of the SIS in order to ensure that these goals are achieved.

1.4 Exclusions

The following aspects of the LV to PL interface are excluded from this SIS:

- Payload destruct systems provided by the space vehicle contractor (SVC)
- Payload adapters provided by the SVC (see Section 3.1.5)

1.5 Definitions

Vehicles:

Launch Vehicle (LV) Segment – The LV segment consists of the means for transporting the payload from the launch site to the delivery orbit, through completion of the contamination and collision avoidance maneuver (CCAM) and upper stage disposal. It includes, but is not limited to, production, assembly, propulsion, guidance and control, electrical power, tracking and telemetry, communication, ordnance, flight termination, payload separation initiation, structural elements, payload fairing, software, and appropriate LV/ground and LV/payload interfaces that are necessary to meet mission requirements. (The payload (the space vehicle (SV), its unique Airborne Support Equipment (ASE), and the payload adapter with its separation system), though transported by the EELV, is not considered part of the EELV system.)

Payload (PL) – The systems provided by the user to be delivered to space. The payload consists of the Space Vehicle(s), space vehicle dispensers (if used), the payload adapter (which joins the user hardware to the launch vehicle at the Standard Interface Plane, as defined herein), user-supplied propulsive elements, the user-supplied separation system, and any user-supplied airborne support equipment (ASE). (Note: SV payloads and the SV bus are considered to be subsystems of the space vehicle and are not discussed in this SIS.)

Space Vehicle (SV) – An autonomous element of the PL that separates at the PL-provided separation plane and is delivered to the defined mission orbit or trajectory.

SV Bus – Generic portions of the SV which provide essential services to support the mission (e.g., station-keeping, attitude control, electrical power, data handling, and communications)

Payload Classes:

Payload Class – Refers to a group of payloads requiring generically the same range of launch vehicle performance capability and launch vehicle environments. Any EELV configuration that meets the performance and environments capabilities may be used to launch the payload and will be specified in the LV/PL ICD. EELV payload classes are divided, based on

performance capability requirements, as Medium Payload Class (MPC), Intermediate Payload Class (IPC), and Heavy Payload Class (HPC).

Medium Payload Class (MPC) – Refers to the class of payloads requiring performance capability at the lower end of the range offered by EELV. The reference performance upper boundary of this class is 8,500 lbs. to GTO. For some SIS requirements, an MPC-S designation is used to indicate conditions experienced by smaller payloads that should be considered during payload design. Unless noted, MPC and MPC-S interface requirements are identical. The MPC uses the 62” bolted SIP and the 4m PLF.

Intermediate Payload Class (IPC) – Refers to the class of payloads requiring performance capability between that of the MPC and the HPC. The performance capability for this class ranges up to 19,000 lbs to GTO based on current LV system performance¹. The IPC uses the 62” bolted SIP as the standard interface and either the 4m or 5m PLF. The IPC encompasses both the 4m IPC and the 5m IPC as sub-classes (different environments). The 5m IPC may use the 173” bolted SIP as an option.

Heavy Payload Class (HPC) – Refers to the class of payloads requiring capability exceeding the IPC performance capability. The HPC uses the 173” bolted SIP and the 5m PLF.

Miscellaneous:

Geosynchronous Transfer Orbit (GTO) – Refers to a reference (or an actual delivery) orbit at 27 degrees inclination with an apogee of 19,300 nm and a perigee of 100 nm.

Standard Interface Plane (SIP) – The SIP is the plane which defines the interface between the LVC-provided and the SVC-provided hardware (fasteners spanning the plane at the SIP shall be provided by the LVC to assure compatibility; electrical wiring across the SIP is the responsibility of the SVC utilizing connector halves provided by the LVC for mating at the SEIP).

Standard Electrical Interface Panel (SEIP) – The structure on which the interfacing LV and PL electrical connectors are supported (Electrical connector halves shall be provided by the LVC to assure compatibility).

User – A generic term referring to the SV SPO and, by extension, to the PL or SV Contractor(s), the Launch Services Integrating Contractor (LSIC) and any of their agents or subcontractors

Requirement Categories:

Mission-Unique – Items or capabilities that are not part of the Standard Interface but could be provided for a particular mission, usually at an additional cost.

¹ Performance numbers may change with program maturity. Payloads exceeding 13,800 lbs. to GTO may not be compatible with all EELV IPC configurations. Contact the EELV SPO for the current vehicle capability.

Mission-Specific – Items or capabilities that are dependent on the specific mission being flown. Unlike “mission-unique” parameters, mission-specific items are not considered to be a capability beyond the standard SIS capability.

Concept Specific – Refers to technical parameters that are dependent on the EELV launch vehicle contractor’s specific design. No attempt has been made to define these parameters in the SIS.

EMISM Categories:

Electromagnetic Interference Safety Margin (EMISM) Event Categories – EMISM safety margins are categorized in accordance with the worst case potential criticality of the effects of interference induced anomalies. The following categories shall be used:

Category I – Serious injury or loss of life, damage to property, or major loss or delay of mission capability

Category II – Degradation of mission capability, including any loss of autonomous operational capability

Category III – Loss of functions not essential to mission

Gaseous Nitrogen Grades:

Grade B Gaseous Nitrogen – Gaseous nitrogen with purity, by volume, of 99.99% minimum. Percent nitrogen includes trace quantities of neon, helium, and small amounts of argon (as defined by MIL-STD-27401P). Maximum total impurities, by volume, are as follows:

Total	100 ppm
Total hydrocarbons as methane	5.0 ppm
Water	11.5 ppm
Oxygen	50 ppm

Grade C Gaseous Nitrogen – Gaseous nitrogen with purity, by volume, of 99.995% minimum. Percent nitrogen includes trace quantities of neon, helium, and small amounts of argon. Maximum total impurities, by volume, are as follows:

Total	50 ppm
Total hydrocarbons as methane	5.0 ppm
Hydrogen	0.5 ppm
Water	5.7 ppm
Oxygen	20 ppm

Air Classes:

Class 5000 (air) – Particle concentration no more than $5000(0.5/d)^{2.2}$ particles/ft³ where d = particle size in microns.

Class 100,000 (air) – Particle concentration no more than $100,000(0.5/d)^{2.2}$ particles/ft³ where d = particle size in microns.

1.6 Acronym List

A	amperes
AGE	aerospace ground equipment
A/C	air conditioning
AC	alternating current
ASE	airborne support equipment
ASTM	American Society for Testing and Materials
Btu	British thermal unit
CCAM	contamination and collision avoidance maneuver
CDR	Critical Design Review
CG	center of gravity
CVCM	collected volatile condensable material
dB	decibel
DC	direct current
dia.	diameter
DOP	dioctyl phthalate
EED	electro-explosive device
EELV	Evolved Expendable Launch Vehicle
EGSE	electrical ground support equipment
ELV	Expendable Launch Vehicle
EM	electromagnetic
EMD	Engineering, Manufacturing, and Development
EMISM	electromagnetic interference safety margin
ESD	electrostatic discharge
F	Fahrenheit
fps	feet per second
ft.	foot
GEO	geosynchronous earth orbit
GHe	gaseous helium
GHz	gigahertz
GN ₂	gaseous nitrogen
GPS	Global Positioning System
GTO	geosynchronous transfer orbit
HEPA	High Efficiency Particulate Air filter
HPC	Heavy Payload Class
hr	hour
Hz	Hertz (frequency)
ICD	Interface Control Document (also called the Mission Specification)
I/O	input/output
IPC	Intermediate Payload Class
kbps	kilobits per second
kHz	kilohertz
kV	kilovolts
LAN	longitude of ascending node
lbs	pounds

LEO	low earth orbit
LCU	liquid cooling unit
LSIC	Launch System Integration Contractor
LV	launch vehicle
LVC	Launch Vehicle Contractor
m	meter
mA	milli-amperes
mg	milligram
MHz	Megahertz
MPC	Medium Payload Class
MPC-S	Medium Payload Class – Smaller Dynamic Envelope
msec	millisecond
NASA	National Aeronautics and Space Administration
NEC	National Electrical Code
NMM	U.S. Air Force Space Command National Mission Model
NRZL	Non-Return to Zero Phase L
NSI	NASA standard initiator
PDR	Preliminary Design Review
PL	payload
PLA	payload adapter
PLF	payload fairing
PMP	Parts, Materials and Processes
psi	pounds per square inch
PSU	propellant servicing unit
RAAN	right ascension of ascending node
RCS	reaction control system
RF	radio frequency
RMS	root mean square
SCAPE	Self Contained Atmospheric Protective Ensemble
SCFH	standard cubic feet per hour
SCFM	standard cubic feet per minute
SEIP	Standard Electrical Interface Panel (located on the LV)
SGLS	Space Ground Link Subsystem
SI	standard interface
SIP	standard interface plane
SIS	Standard Interface Specification
SIWG	Standard Interface Working Group
SPI	standard payload interface
SPO	System Program Office
SPRD	System Performance Requirements Document
SV	Space Vehicle
SVC	Space Vehicle Contractor (or its agents)
SVIP	space vehicle interface panel (located in the EGSE Room)
TBD	to be determined (by Government)
TBR	to be reviewed (jointly by Government and Contractors)
TBS	to be supplied (by Contractors)

EELV - Standard Interface Specification – Version 6.0

TML	total mass loss
uSec	microsecond
V	volts
VDA	vacuum-deposited aluminum
VDC	volts direct current
VDG	vacuum-deposited germanium
W	watts

1.7 Reference Documents

1. EWR 127-1, Eastern and Western Range, Range Safety Requirements, 31 Mar 1995.
2. MIL-P-27401C, Propellant Pressurizing Agent, Nitrogen, 20 Jan 1975.
3. EELV System Performance Requirements Document (SPRD), 5 October 1998.

2. MISSION REQUIREMENTS

2.1 Orbit Requirements

2.1.1 Throw Weight

Requirements are as stated in the main portion of the SPRD, Section 3.2.1.1 (Performance: Mass to Orbit).

2.1.2 Orbit Insertion and Accuracy

Requirements are as stated in the main portion of the SPRD, Section 3.2.1.2 (Performance: Accuracy).

2.1.3 Launch Window

The EELV shall have sufficient capability to deliver the required payload mass (including payload growth, performance margin, and flight performance reserve) to the correct orbit when launched at any time within a mission-dependent launch window as negotiated in the LV/PL ICD.

2.1.4 Attitude Rates and Accuracies

During park orbit or transfer orbit coasts, the EELV shall be capable of providing passive thermal control by orienting the roll axis of the upper stage/payload to passive thermal control attitude and holding attitude to within ± 5 degrees (3 sigma). Also, during park orbit or transfer orbit coasts, the EELV shall be capable of providing a commanded roll rate in either direction of between 0.5 and 1.5 degrees per second (MPC) and between 0.5 and 1.0 degrees per second (IPC and HPC) as negotiated in the LV/PL ICD.

Prior to separation, the EELV shall be capable of pointing the upper stage/payload to any desired attitude and either minimizing all rotation rates (3-axis stabilized missions) or providing a spin about the longitudinal axis (spin-stabilized missions). For 3-axis stabilized missions, attitude errors shall be no greater than 1.4 degrees (3 sigma) about each axis and rotation rates shall be less than 0.2 degree/sec (3 sigma) in pitch and yaw and 0.25 degree/sec (3 sigma) in roll. For spin-stabilized missions, the LV used for the MPC shall have the capability to provide payload spin rates of 5 ± 0.5 (3 sigma) rpm with spin axis orientation accurate to within 1.75 degrees (3 sigma), assuming a maximum 0.5" payload CG offset; the LV used for the IPC shall have the capability to provide payload spin rates of 5 ± 0.5 (3 sigma) rpm with spin axis orientation accurate to within 3.5 degrees (3 sigma), assuming a maximum 0.5" payload CG offset. (HPC missions requiring spin at separation have not been identified.)

2.1.5 Separation Requirements

2.1.5.1 Separation Mechanism

The PL separation mechanism to separate the SV from the PLA is to be provided by the SVC.

2.1.5.2 Separation Velocity

The PL Separation System shall impart a minimum of 1 ft/sec relative separation velocity between the SV and the LV/PLA at separation.

2.1.5.3 Separation Inhibits

The LV shall be capable of enabling/inhibiting the LV Reaction Control System (RCS) during SV separation operations. As required by specific mission(s), the RCS shall be inhibited up to 1 second before and up to 5 seconds after SV separation.

2.1.5.4 Separation Contingencies

The Launch Vehicle shall have the flexibility to incorporate mission-unique nominal and contingency flight sequences. Mission-unique flight sequences shall be negotiated and documented in the LV/PL ICD.

2.1.5.5 Contamination and Collision Avoidance Maneuvers

Contamination and collision avoidance maneuvers (CCAMs) shall be designed to preclude re-contact with the SV and to minimize SV exposure to LV contaminants. Requirements for contamination levels are specified in Section 3.5.4.

3. PHYSICAL INTERFACES

3.1 Mechanical Interfaces

3.1.1 Interface Definitions

The Cartesian coordinate system shown in Figure 1 shall be used for the PL/LV interface reference, placing the origin in the center of the standard interface plane. It is a right-handed coordinate system: the positive X-axis is along the centerline of the vehicle and points up toward the top of the vehicle. Additionally, the axial axis is defined to be the X-axis and lateral axes are defined to be the Y- and Z-axes with clocking as defined in the LV/PL ICD.

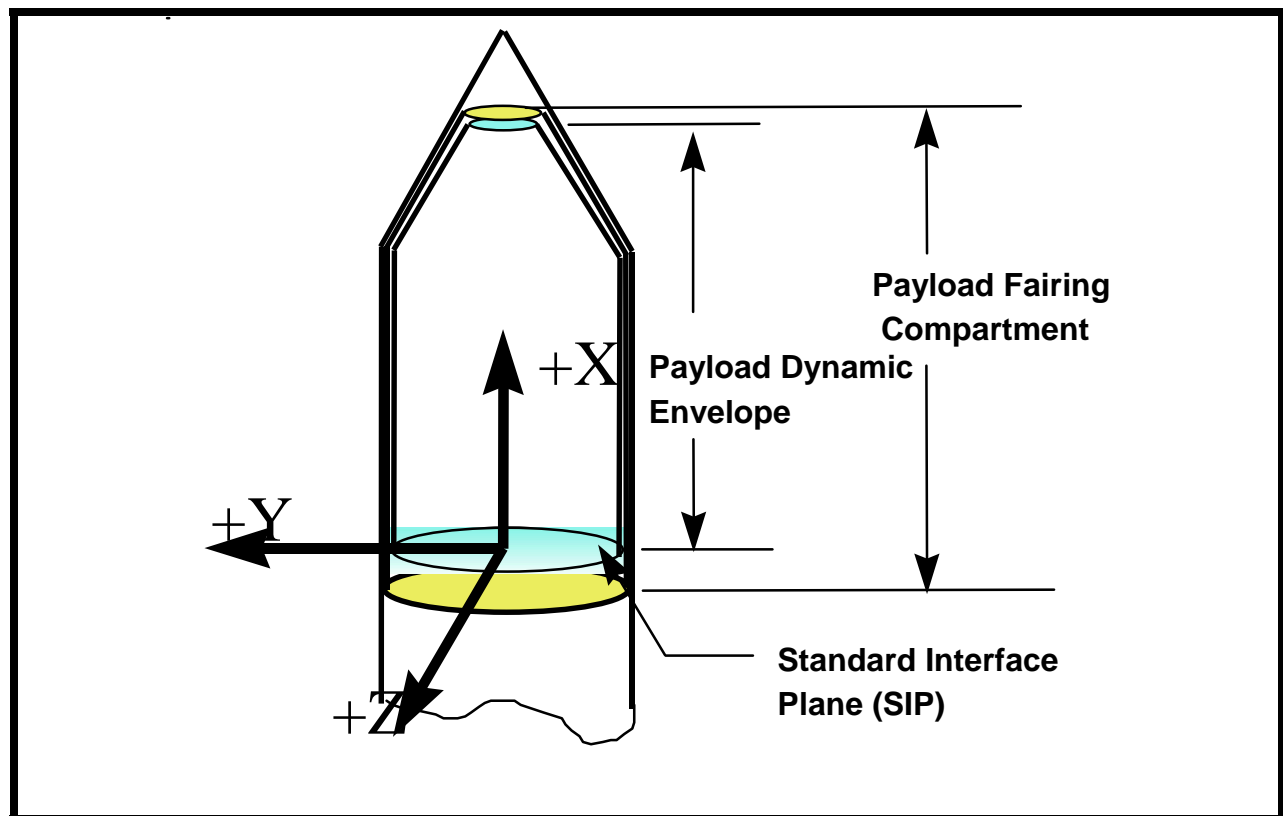


Figure 1 - EELV Standard Interface Coordinate System

Some items discussed in subsequent sections of this document are shown in Figure 2. This Figure shows the relation of the SIP to the PL and the LV structures near the SIP.

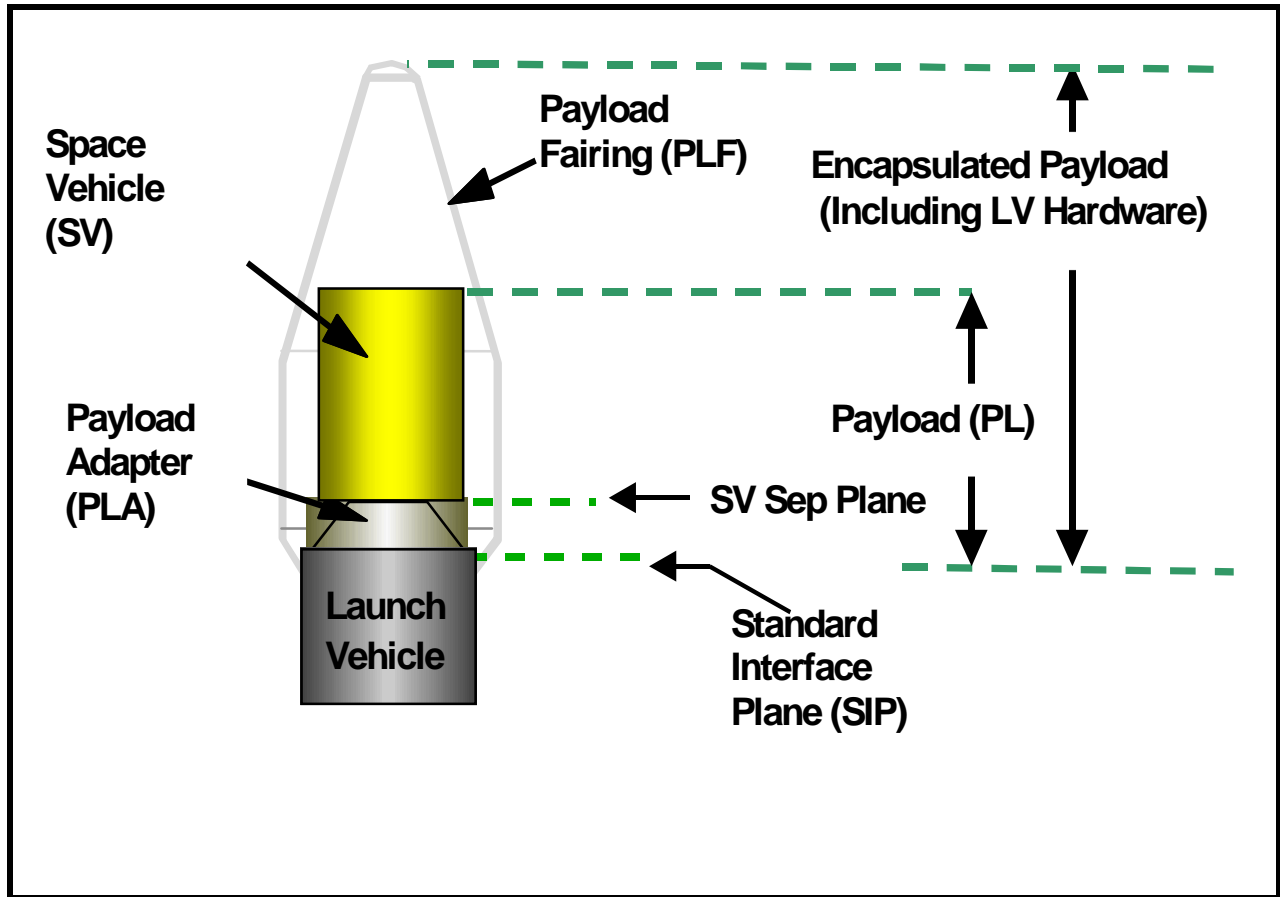


Figure 2 - Standard Interface Plane - Relationship to LV and Payload

3.1.2 Mating Surface

3.1.2.1 Bolt Pattern

The LVC supplies one of two standard mechanical interfaces (one for the MPC and the IPC and one for the HPC). This interface joins the LV to the payload. For the MPC and IPC, the bolt pattern has a 62.010" diameter as shown in Figure 3.

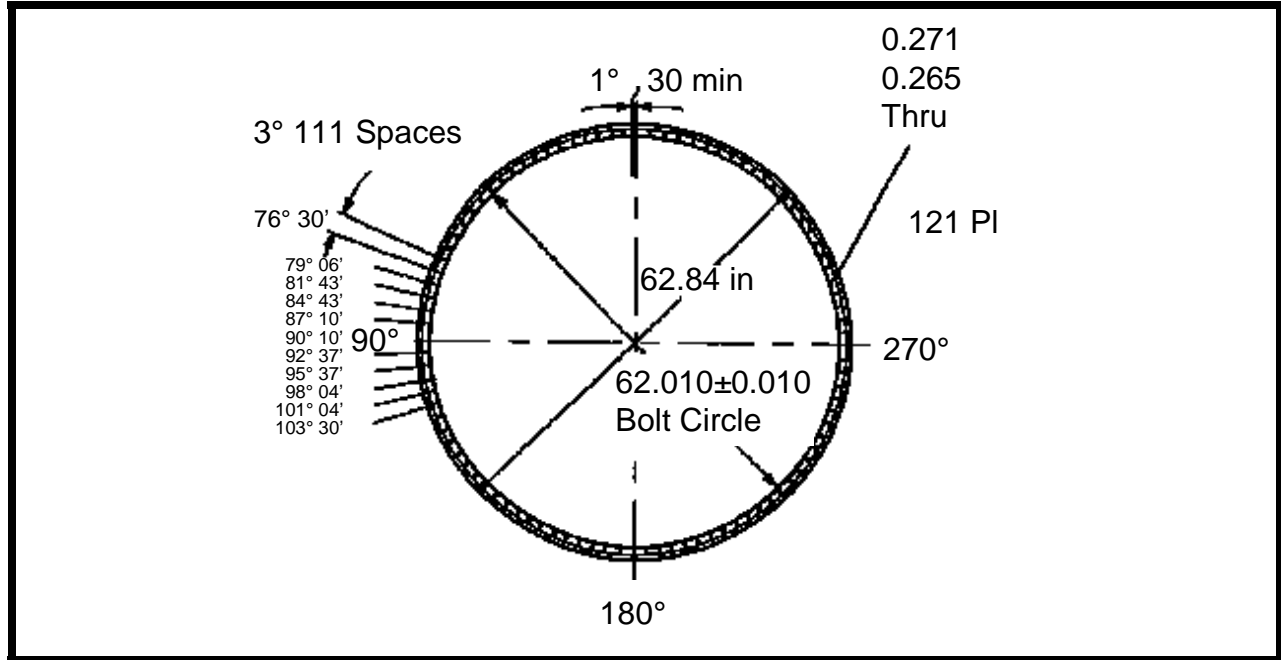


Figure 3 - Small Diameter (62.010") Payload Interface

The HPC standard interface has a 173” diameter bolt pattern as shown in Figure 4. (The 5m IPC may also use the 173” diameter bolt pattern as an option.) This bolt pattern is intended for use with the HPC GEO mission class and is not required to be used with the HPC LEO mission. Contact the EELV SPO for limits on mass and center-of gravity locations of existing interface designs. The interface for the HPC and 5m IPC heavy LEO mission is **TBD**.

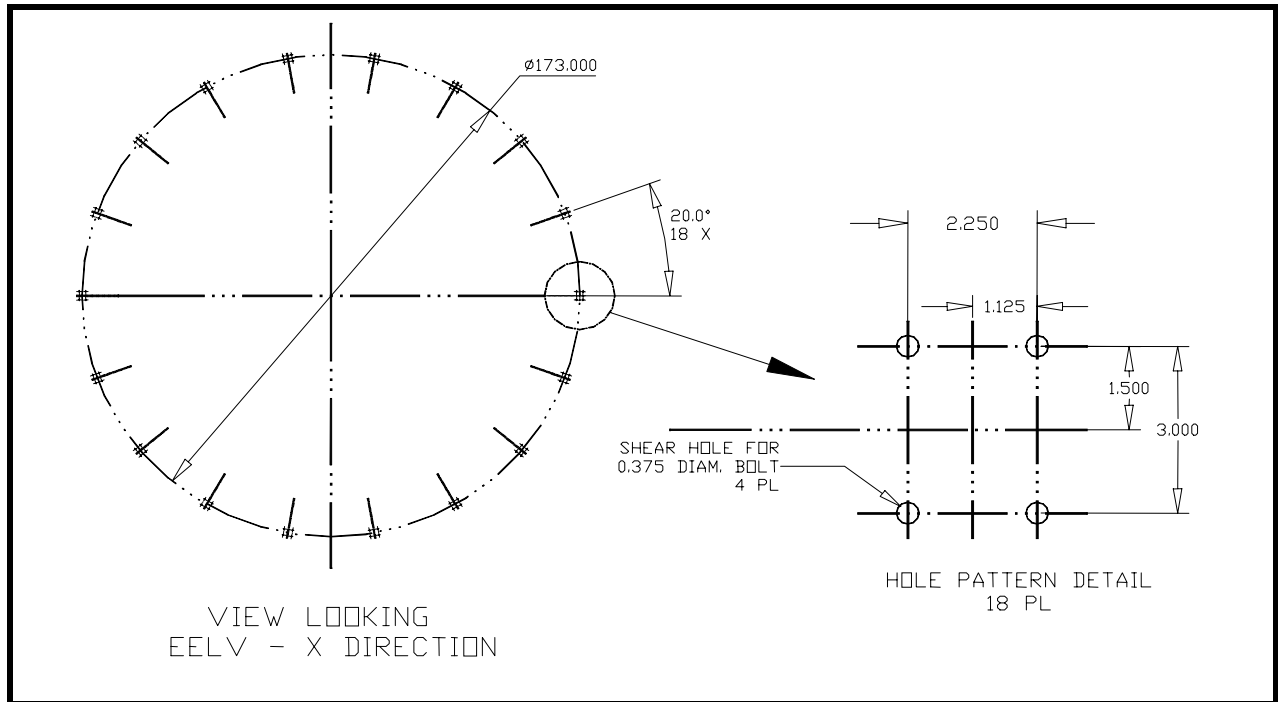


Figure 4 - Large Diameter (173'') Payload Interface

3.1.2.2 Flatness

The flatness of EELV mating surfaces at the SIP are defined by a theoretical zone in which any point on the interface must fall within the parallel plane extremities as shown in Figure 5. For the 62” payload interface, these surfaces shall be flat to within 0.015 inch (15 Mils). For the 173” payload interface, these surfaces shall be flat to within 0.030 inch (30 Mils).

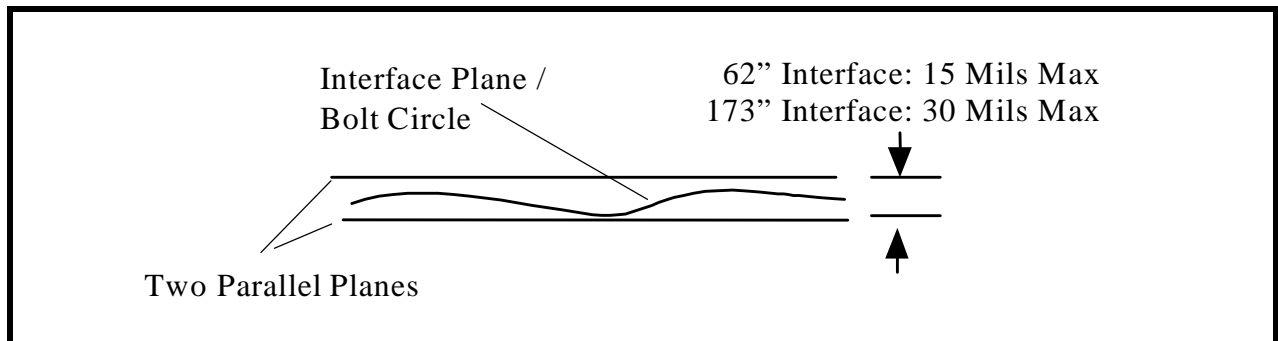


Figure 5 - EELV Standard Interface Flatness Requirement

3.1.2.3 Master Gauge

The LVC shall provide a master gauge to the SVC for SI hole pattern drilling.

3.1.3 Payload Dynamic Envelopes

The payload dynamic envelope is defined as the volume that the payload may safely occupy when allowing for payload motion during dynamic conditions, including launch processing, flight, and PLF separation. Motion of the LV has been accounted for in defining the specific dynamic envelope.

There are four standard **minimum** sizes for payload dynamic envelopes which are derived from the payload fairing size (actual payload dynamic envelopes may be larger). These envelopes define the useable volume inside the fairing and forward of the SIP as shown in Figure 1. However, there may be some stay-out zones in the payload dynamic envelope that are concept-specific and may impact payload design. Users are advised to coordinate closely with the EELV SPO to ensure that their payload designs and support equipment do not violate these stay-out zones. Payload fairing dynamic envelopes shall accommodate existing payloads.

For the HPC, the payload dynamic envelope is shown in Figure 6.

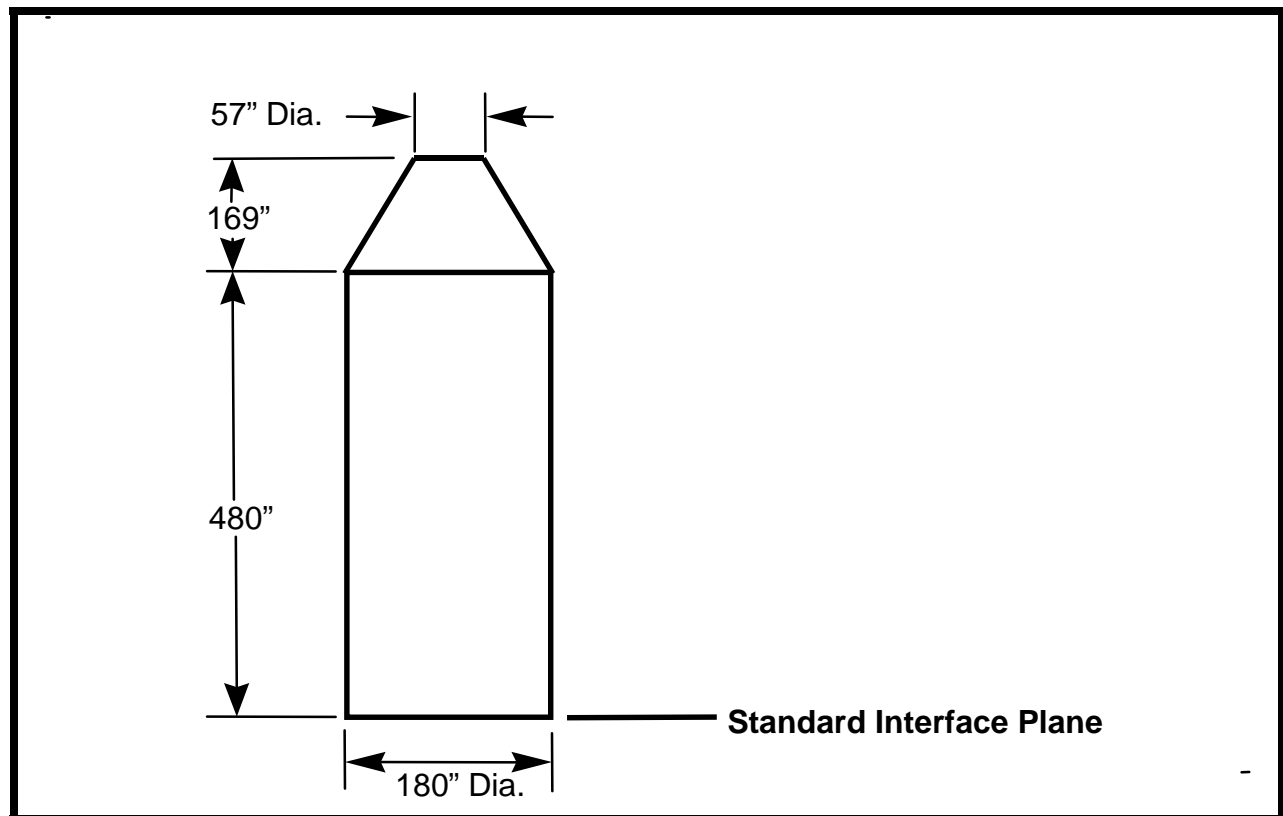


Figure 6 - EELV HPC Dynamic Envelope

For the 5m IPC, the minimum dynamic envelope is shown in Figure 7; shorter or narrower payloads may use an appropriate concept-specific PLF at the option of the LVC after coordination with the SVC and/or LSIC.

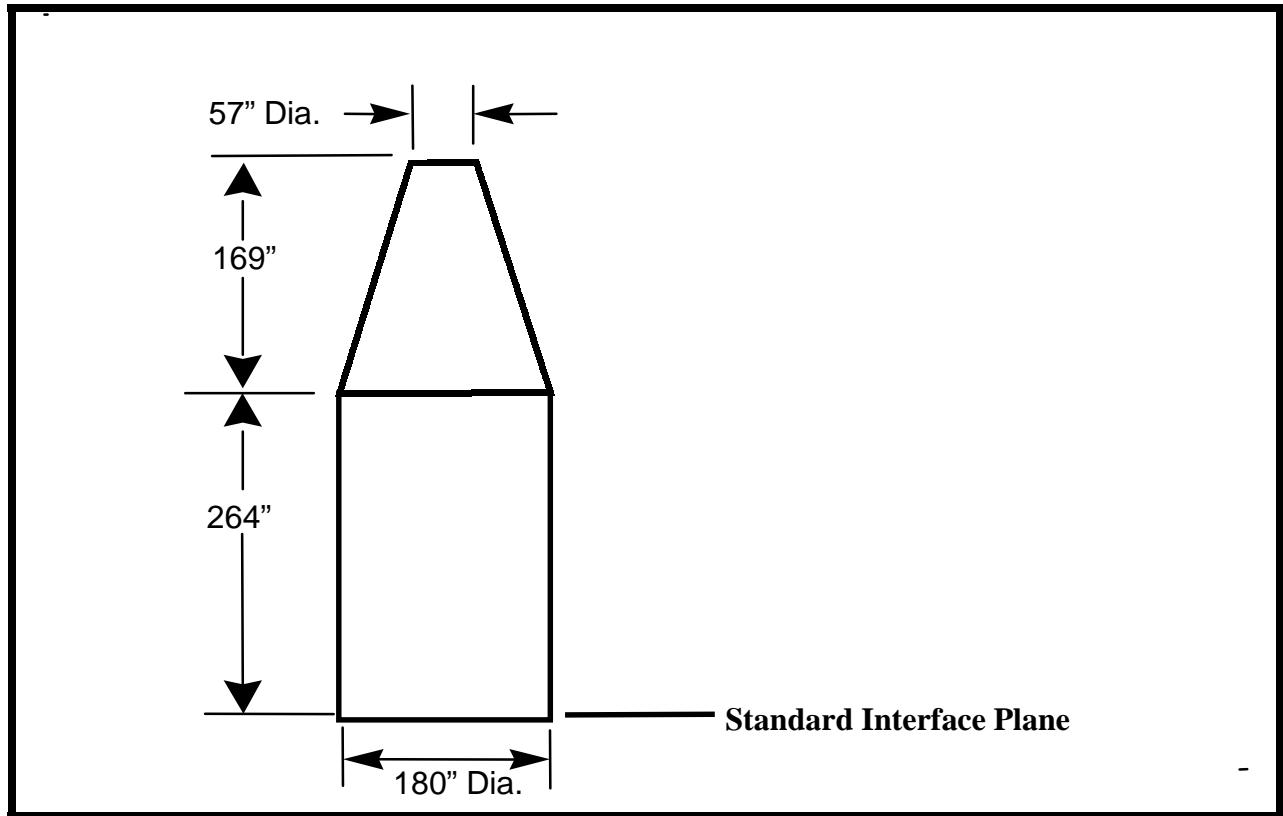


Figure 7 - EELV 5m IPC Dynamic Envelope

The nominal dynamic envelope size for the MPC and the 4m IPC is as shown Figure 8. Where the payload does not require the nominal MPC size, a smaller dynamic envelope, shown in Figure 9, may be substituted at the option of the LVC after coordination with the SVC and/or LSIC.

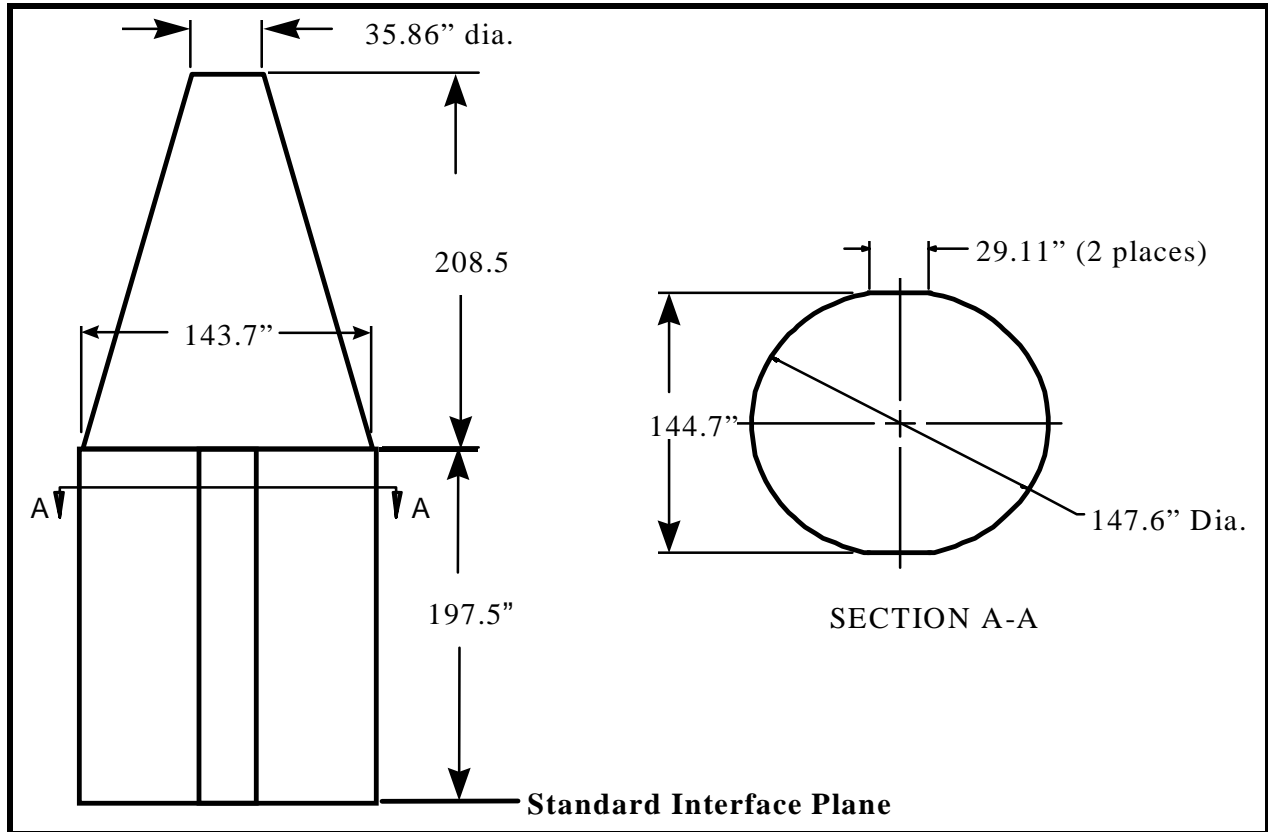


Figure 8 – EELV MPC and 4m IPC Dynamic Envelope

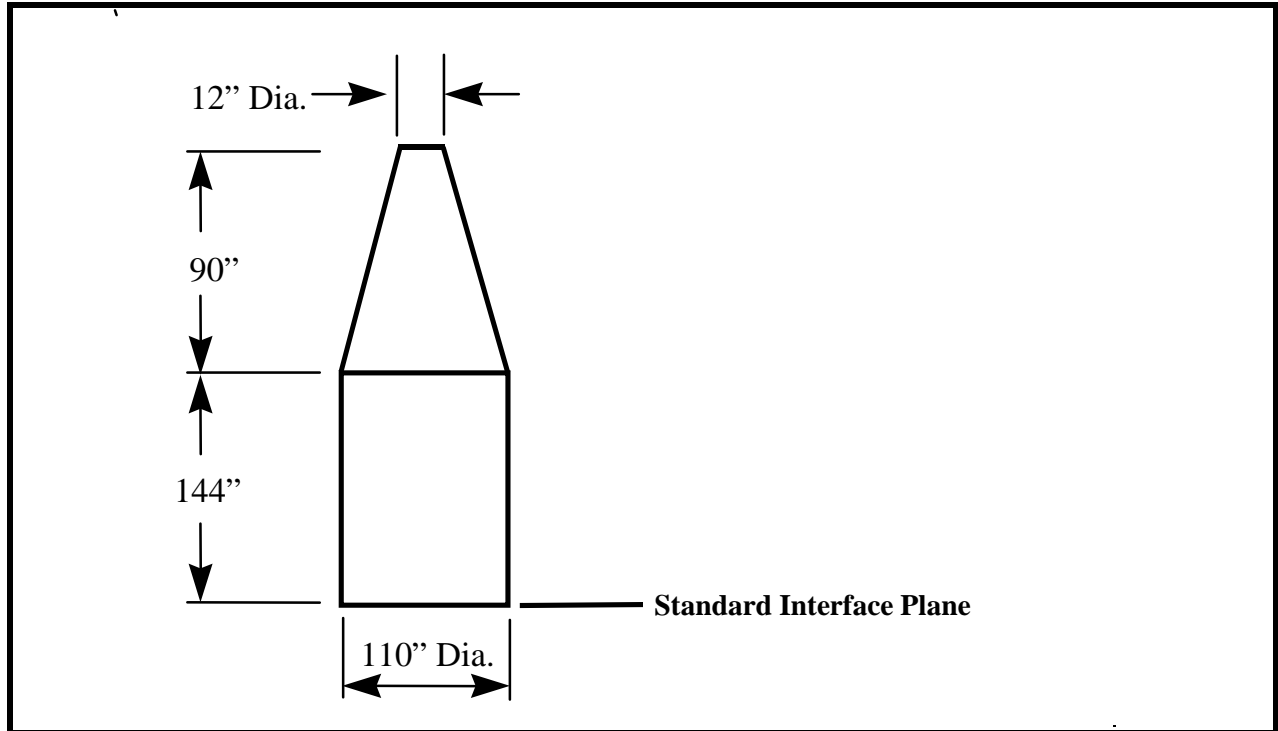


Figure 9 – EELV Smaller (Optional) MPC-S Dynamic Envelope

3.1.4 PLF Access Doors

3.1.4.1 Routine Access

As a standard service, the LVC shall provide two doors in the payload fairing for personnel access to the payload. The doors may, in general, be placed anywhere on the fairing cylindrical section subject to “stay-out zone” restrictions arising from structural, harness routing, and facility access considerations.

Other doors (in addition to the two standard doors) for additional routine access to the payload may be provided on a mission-unique basis.

3.1.4.2 Emergency Access

The LVC shall provide a capability for emergency access to the payload by installing emergency access doors (subject to “stay-out zone” restrictions) or by defining areas of the fairing where emergency access doors can be cut; in either case, the doors shall be of a size that allows a person wearing a Self Contained Atmospheric Protective Ensemble (SCAPE) suit to reach in with both hands. These areas are near the bottom of the PLF barrel and are 48 ± 12 inches above the SIP.

3.1.5 Payload Adapters

The payload adapter (PLA) interfaces with the LV at the Standard Interface Plane. All payload adapters shall be SVC-provided equipment. Adapters to accommodate existing payload interfaces for use on EELV are the responsibility of those SVCs.

3.1.6 Payload Mass Properties

3.1.6.1 Center of Gravity Location

To preclude the need for mission-unique payload attachment hardware, the location of the payload center of gravity (CG) along the SI X-axis, as measured from the SIP, shall be restricted to the acceptable region (to the left or below the lines) shown in Figure 10. To avoid unacceptable lateral loads, the CG in the lateral directions (SI Y- and Z-axes directions) shall be limited to less than 5 inches offset from the vehicle centerline for MPC and HPC missions in which the LV/PL stack is 3-axis stabilized at separation, to less than 4 inches offset from the vehicle centerline for IPC missions in which the LV/PL stack is 3-axis stabilized at separation, and to within 0.5 inches for low spin rate (≤ 5.5 rpm) missions. (Currently, there are no plans for higher spin-rate missions.)

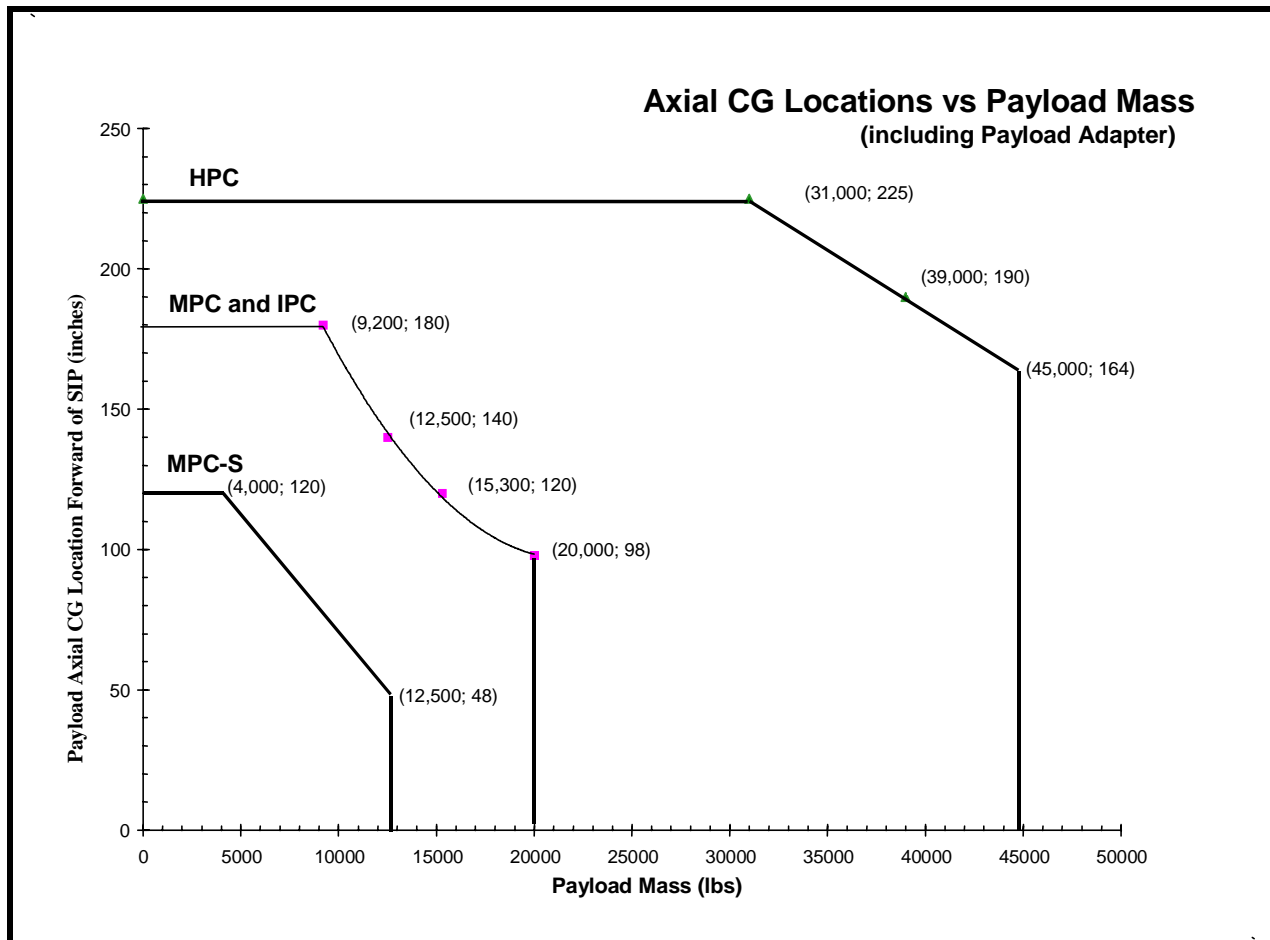


Figure 10 - Allowable CG Location Using Standard PL Attachment Hardware

3.1.6.2 Payload Mass Properties

The LV system shall accommodate payloads with the mass properties indicated in Table 1. The mass properties are not intended as absolute limits to payloads, but only as design requirements for the LV controls system. Payloads with exceedances of some of the features specified in these tables may be accommodated as well, as negotiated in the LV/PL ICD. Note that the payload includes the SV, payload adapter, its airborne support equipment, and its separation system. The coordinate axes are as specified in Figure 1.

EELV Mission Class	PL Spin Rate at Separation (rpm)	PL Mass (lbs)	PL CG Location (inches forward of SIP)	Max PL Lateral CG Offset (in.)	PL Moments of Inertia (slug-ft sq)	PL Products of Inertia (slug-ft sq)	Notes
MPC-S	3-Axis Stabilized	2,000 – 8,000	40 – 110	5	$I_{xx} = 300 - 4500$ $I_{yy} = 285 - 8000$ $I_{zz} = 285 - 8000$	$I_{xy} = -400 \text{ to } +400$ $I_{xz} = -400 \text{ to } +400$ $I_{yz} = -400 \text{ to } +400$	1
MPC-S	5	2,000 – 4,500	40 – 110	0.5	$I_{xx} = 300 - 3000$ $I_{yy} = 285 - 2000$ $I_{zz} = 285 - 2000$	$I_{xy} = -50 \text{ to } +50$ $I_{xz} = -50 \text{ to } +50$ $I_{yz} = -250 \text{ to } +250$	1, 2, 3
MPC	3-Axis Stabilized	2,000 - 16,900	40 – 180	5	$I_{xx} = 500 - 8000$ $I_{yy} = 750 - 12,800$ $I_{zz} = 750 - 12,800$	$I_{xy} = -670 \text{ to } +670$ $I_{xz} = -670 \text{ to } +670$ $I_{yz} = -670 \text{ to } +670$	1
MPC	5	5,800 - 10,500	40 – 160	0.5	$I_{xx} = 1900 - 4000$ $I_{yy} = 1300 - 5000$ $I_{zz} = 1300 - 5000$	$I_{xy} = -50 \text{ to } +50$ $I_{xz} = -50 \text{ to } +50$ $I_{yz} = -250 \text{ to } +250$	1, 2, 3, 4
4 m IPC	3-Axis Stabilized	7,000 – 23,000	40 – 180	3.5	$I_{xx} = 1,900 - 8,000$ $I_{yy} = 1,300 - 12,800$ $I_{zz} = 1,300 - 12,800$	$I_{xy} = -670 \text{ to } +670$ $I_{xz} = -670 \text{ to } +670$ $I_{yz} = -670 \text{ to } +670$	1, 4
5m IPC	3-Axis Stabilized	6,000 – 29,000	40 – 225	3.5	$I_{xx} = 500 - 19,500$ $I_{yy} = 750 - 60,000$ $I_{zz} = 750 - 60,000$	$I_{xy} = -7000 \text{ to } +7000$ $I_{xz} = -7000 \text{ to } +7000$ $I_{yz} = -7000 \text{ to } +7000$	1, 4
4m or 5m IPC	5	2,000 – 12,500	40 – 180	0.5	$I_{xx} = 300 - 4000$ $I_{yy} = 285 - 7000$ $I_{zz} = 285 - 7000$	$I_{xy} = -50 \text{ to } +50$ $I_{xz} = -50 \text{ to } +50$ $I_{yz} = -250 \text{ to } +250$	1, 2, 3, 4
HPC LEO	3-Axis Stabilized	27,000 - 42,000	150 - 215	5	$I_{xx} = 11,000 - 29,500$ $I_{yy} = 50,000 - 130,000$ $I_{zz} = 50,000 - 130,000$	$I_{xy} = -7000 \text{ to } +7000$ $I_{xz} = -7000 \text{ to } +7000$ $I_{yz} = -7000 \text{ to } +7000$	1
HPC GEO	3-Axis Stabilized	5,400 - 13,500	85 - 225	5	$I_{xx} = 3,000 - 19,500$ $I_{yy} = 5,000 - 60,000$ $I_{zz} = 5,000 - 60,000$	$I_{xy} = -7000 \text{ to } +7000$ $I_{xz} = -7000 \text{ to } +7000$ $I_{yz} = -7000 \text{ to } +7000$	1
Notes: 1. Values in the table represent the range of capability and the full range for all columns may not be available simultaneously (e.g., mass and cg location combinations are subject to the restrictions shown in Figure 10). 2. These are payloads requiring spin at separation. 3. Pre-PL separation spin-up maneuver acceptable; indicated rate not required throughout flight. 4. Payload cg location forward of SIP restricted to 100 inches or less for 5800 lbm payload. Linear interpolation from that point to 160 inches forward of SIP for 10,500 lbm payloads.							

Table 1 - Payload Mass Properties**3.1.7 Payload Stiffness**

To avoid dynamic coupling between low frequency launch vehicle and payload modes, heritage and transition payloads (as designated by the EELV SPO) should be designed such that the stiffness of the PL structure exhibits fundamental frequencies greater than the values shown in Column A of Table 2 (when cantilevered from a fixed base at the SIP). Newer payloads (not designated by the EELV SPO as heritage/transition payloads) should be designed such that the

stiffness of the payload structure exhibits fundamental frequencies greater than those shown in Column B of Table 2 (when cantilevered from a fixed base at the SIP).

These recommendations provide guidelines for the design of payload structures based on historical experience and design practices. Payloads with fundamental frequencies less than these values can be evaluated through mission-unique analyses.

Payload Class	Axis	Column A: Fundamental Frequency (Hz) for Heritage PLs (including PLA)	Column B: Fundamental Frequency (Hz) for New PLs (including PLA)
MPC-S	Lateral	12	12
	Axial	30	30
MPC	Lateral	8	10
	Axial	15	20
IPC	Lateral	N/A	10
	Axial	N/A	20
HPC	Lateral	2.5	2.5
	Axial	15	15

Table 2 - Payload Stiffness Recommended Fundamental Frequencies

3.2 Electrical/Avionics Interfaces

The EELV system shall provide umbilical electrical interconnection from the time of T-0 umbilical installation until its separation at lift-off. All payload-provided signals and power will be handled as unclassified data.

3.2.1 Electrical Connections at LV/Payload Interface

The EELV system shall provide interface airborne electrical interconnection services from the time of payload mate (electrical) to the time of SV separation. The electrical interface between the payload and the LV will be at the standard electrical interface panel (SEIP) as shown in Figure 11. The SEIP is provided by the LVC and is located near the SIP with clocking as defined in the LV/PL ICD. Wiring harnesses from the payload to the SEIP shall be provided by the SVC. The SEIP shall be accessible after payload/LV mate for connection of payload wiring harnesses. The LVC shall provide the mating connector halves to the SVC to mate to matching connectors at the SEIP. This ensures the connectors, pins and sockets are all procured from the same vendor to the same specifications, minimizing any potential for a mismatch.

3.2.2 Electrical Connections at EGSE Room

The payload electrical ground support equipment (EGSE) interface connection will be at the EGSE room interface panel as shown in Figure 11. Space shall be provided in the EGSE room

such that the maximum distance between the payload EGSE and the EGSE room interface panel is less than 15 feet.

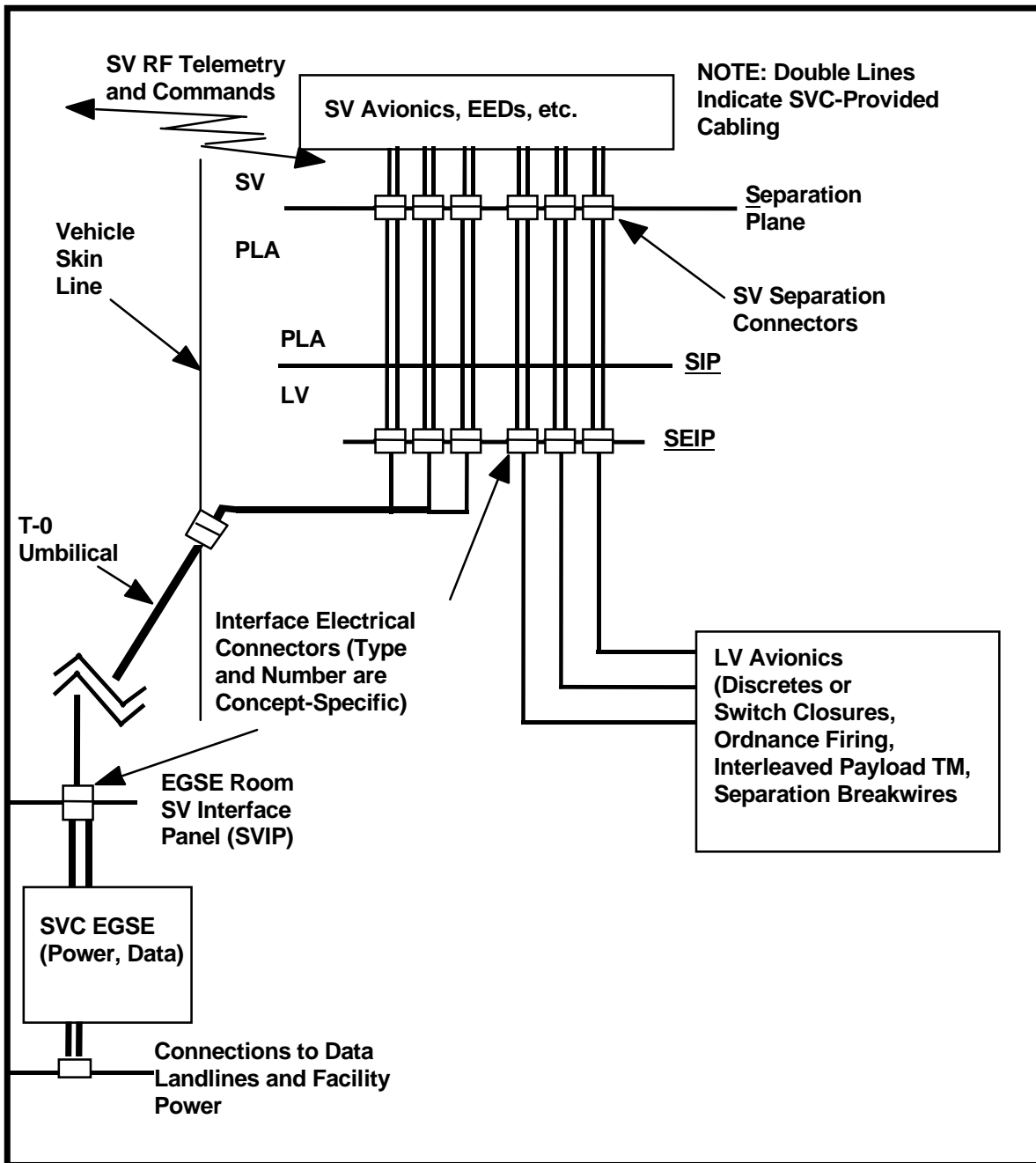


Figure 11- Interface Wiring Harness Connections

The LVC shall provide the mating connector halves to the SVC to mate to the EGSE room interface panel. This ensures the connectors, pins and sockets are all procured from the same vendor to the same specifications, minimizing any potential for a mismatch.

3.2.3 Payload Electrical Connector Separation

At the time LV/PL electrical connectors are to be separated, the current on any line shall be no greater than 10 milliamps. This applies to LV/PL interfaces in the T-0 umbilical and in PL separation connectors.

3.2.4 Ground Interfaces

The LV and the EELV ground facility shall provide dedicated "feed-through" cabling from the SEIP, through an LV umbilical, to an LVC-provided EGSE room SV Interface Panel (SVIP) for both power to, and sensor signals from, the SV. Cabling connectivity shall be available from the time the T-0 umbilical is connected until it is disconnected at liftoff.

Each wire of this dedicated cabling shall be isolated from the LV structure by a minimum of one megohm, measured before any connection to the payload or payload ground equipment.

3.2.4.1 Ground Power

The LV and the EELV ground facility shall provide twelve (12) twisted-pairs for payload power that may include external power, full-power battery charging power, trickle battery charging power, or other power as required by the payload

When used by the payload, each twisted-pair constitutes part of a complete circuit, with a power source in the EGSE room and a load in the payload, and shall meet the following requirements at the SVIP interface:

Source Voltage: 126 VDC maximum

Source Current: 11 Amps maximum

The maximum round-trip resistance attributed to this cabling between the SEIP and SVIP for any one pair shall be 1.0 ohms, or less, when shorted at the opposite end.

The power return lines at the payload EGSE power source shall be isolated from earth ground by 1 ± 0.1 megohm by the SVC, and shall be referenced to a single point ground at the payload structure.

Payload power dissipation will be typically less than 1200 watts (average/steady state) with peak power and duration constrained by the LV cooling capabilities as described in Section 3.3.2.1. Peak power of 2200 watts for one hour, for example, is within the envelope of Section 3.3.2.1.

3.2.4.2 Power Leads and Returns

All primary and secondary power leads shall be routed with an accompanying return lead. Power conductors shall be twisted pairs, unless it is necessary to use heavy gage, which does not lend itself to twisting. In this case, the high and return conductors shall be routed along a parallel path, and shall be laced or spot tied together to obtain maximum field cancellation. Connector types will be negotiated as a part of the LV/PL ICD process.

3.2.4.3 Power Isolation

The dedicated feed-through cabling shall be isolated from the LV structure by a minimum of 1 megohm.

3.2.4.4 Ascent Power

The LV will not provide power to the payload following LV ignition and during flight as a part of the SI. Prior to launch, power is provided by means of facility power provided to the payload ground support equipment, which is routed to the payload as described in Sections 3.2.4.1 and 3.2.4.2. This power is available to the payload until the “launch commit” point in the countdown, which occurs shortly before launch. The exact timing of the launch commit point is concept-specific.

3.2.4.5 Ground Support Equipment Power

The EELV ground facility shall provide three-phase uninterruptible power to payload ground equipment with the following characteristics:

Voltage:	120/208 volts \pm 5%
Frequency:	60 Hz \pm 1 Hz
Total Harmonic Distortion (THD):	shall not exceed 5%
Voltage transients:	shall not exceed 200% nominal rms voltage for more than 20 micro-seconds
Maximum Load:	20 KVA

3.2.4.6 Ground Monitoring

The LV and the EELV ground facility shall provide 60 shielded twisted-pairs for the differential monitoring of power and sensor loads in the payload by the payload ground equipment in the EGSE room. These pairs may be used to monitor SV bus voltage, battery voltage sense, battery temperature, battery pressure, or other payload health measurements as required by the SVC. These twisted pairs may also be used to provide commands or additional power from the payload ground equipment to the payload.

When used by the payload, each twisted-pair constitutes part of a complete circuit between the payload and payload ground equipment and shall meet the following requirements at both the SEIP and SVIP interfaces:

Source Voltage:	126 VDC maximum
Source Current:	3.0 Amps maximum

The maximum round-trip resistance attributed to this cabling between the SEIP and SVIP for any one pair shall be 5.0 ohms, or less, when shorted at the opposite end.

Some of the ground monitoring lines may be assigned to carry payload power if the SVC so chooses. In this case the power return lines at the payload EGSE power source shall be isolated from earth ground by 1 ± 0.1 megohm by the SVC, and shall be referenced to a single-point ground at the PL structure. All other circuits shall continue to be isolated from earth ground by at least one megohm.

3.2.5 Flight Command and Telemetry Interfaces

3.2.5.1 Signal Reference

All signals shall have a dedicated signal return line which is referenced at the source.

3.2.5.2 LV to PL Commands

The LVC shall provide 8 redundant pairs of SVC-definable control commands, which can be configured either as 28-volt discretes or as switch closure functions. The SVC shall select either all discrete commands or all switch closures.

The LV telemetry shall indicate the state of each command.

The LVC shall provide the capability to issue the commands in any sequence with a maximum of ten events per command. An event is defined as the change of state (on or off) of one of the commands.

The capability shall be provided to reference the initiation of commands to Upper Stage guidance events, mission times, and/or selected mission scheduled events.

3.2.5.2.1 Discrete Commands

The LV provided discrete commands shall have the following characteristics at the SEIP:

Voltage “On” state:	+23 VDC minimum to +33 VDC maximum
Current:	500 mA maximum per discrete
Pulse Width:	10 sec maximum, 20 msec minimum

The discrete command circuits in the payload shall be isolated from payload structure by a minimum of 1 megohm.

3.2.5.2.2 Switch Closure Functions

The LVC-provided switch closure functions shall accommodate the following electrical characteristics at the SEIP:

Voltage:	+22 VDC minimum to +32 VDC maximum
Current:	1 Ampere maximum
Pulse Width:	10 sec maximum, 20 msec minimum
Leakage Current	1 mA

The switch closure circuits in the LV shall be isolated from LV structure by a minimum of 1 megohm.

3.2.5.3 LV/PL Telemetry Interface

The LVC shall provide the capability to accept two channels of serial data from the payload at the SEIP for interleaving into the LV's telemetry stream to the ground. The LVC shall make available, in near real time, the de-interleaved SV telemetry as specified by the LV/PL ICD.

Each channel shall consist of both a data circuit, using non-return to zero – phase L (NRZL), and a clock circuit. When utilized by the PL, each circuit shall consist of a differential RS-422 line driver pair from the PL and a corresponding differential receiver in the LV. Data shall be sampled by the LV on the false-to-true (logic low to high) transition of the clock.

The LV shall be capable of receiving at least two kbps of data per channel. The data rate from the payload shall not exceed two kbps per channel. However, the combined data rate of both channels shall not exceed two kbps at any one time. Data format and content requirements imposed on the SVC will be defined by the SV/PL ICD.

3.2.5.4 SV Radio Frequency Links

The LVC shall facilitate the transmission of SV RF telemetry, both during ground operations and from liftoff through SV separation. The LVC does not provide encryption for SV telemetry or data whether broadcast (RF) or hard-line. All telemetry will be handled as unclassified data (both on the ground and in flight). The LVC shall facilitate RF uplink commands to the SV during ground operations through liftoff.

3.2.5.5 State Vector Data

There is no provision for furnishing state vector or attitude data directly across the SIP to the SV at SV separation. SVs needing state vector or attitude data will be handled on a mission-unique basis.

When required by the SVC, the best estimate of state vector and attitude data at the time of separation detection will be provided to the spacecraft operators in as close to real time as possible (with a maximum of 20 minutes) after receipt of data at the LVC's facility.

3.2.6 Electromagnetic Compatibility

The requirements for electromagnetic compatibility are outlined in the following sections. These

requirements may be tailored for each specific payload. Individual payload circuit susceptibilities will be addressed as part of the negotiated LV/PL ICD process.

3.2.6.1 Radiated Emissions

Unintentional radiated narrowband magnetic field levels produced by subsystems, and components are mission-unique and will be negotiated as part of the LV/PL ICD process.

3.2.6.1.1 SV Radiation Narrowband

The payload intentional and unintentional radiated emissions shall not exceed the maximum allowable emissions curve of Figure 12. Information on the SV emitters and receivers (power, frequency, E-field levels, and sensitivity of receivers) shall be supplied to the LVC as necessary. The limit applies at the SIP, and shall account for the increased field level caused by radiating inside the fairing cavity. Payload emitter radiation inside an enclosed fairing will create standing waves and exceed the field levels calculated assuming free-space conditions. Payload fairing RF energy focusing shall be considered when determining the maximum field levels at the SIP.

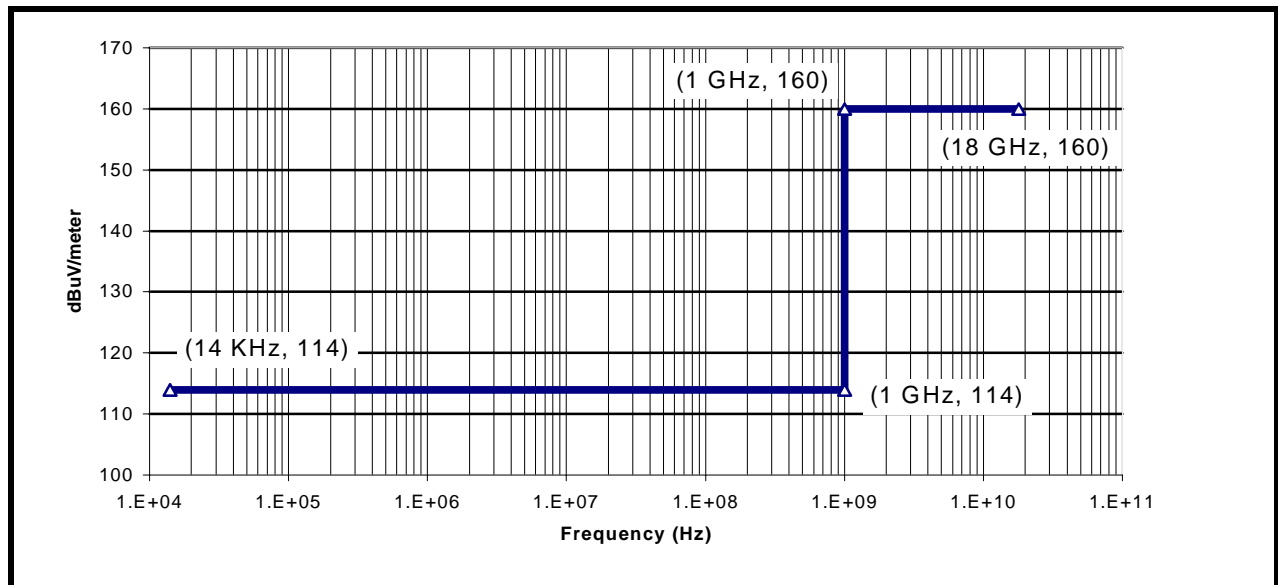


Figure 12 - Maximum Allowable Narrowband SV Radiated E-Fields

3.2.6.1.2 SV Radiation Broadband

The SV unintentional broadband radiated emissions shall not exceed the maximum allowable emissions curve of Figure 13.

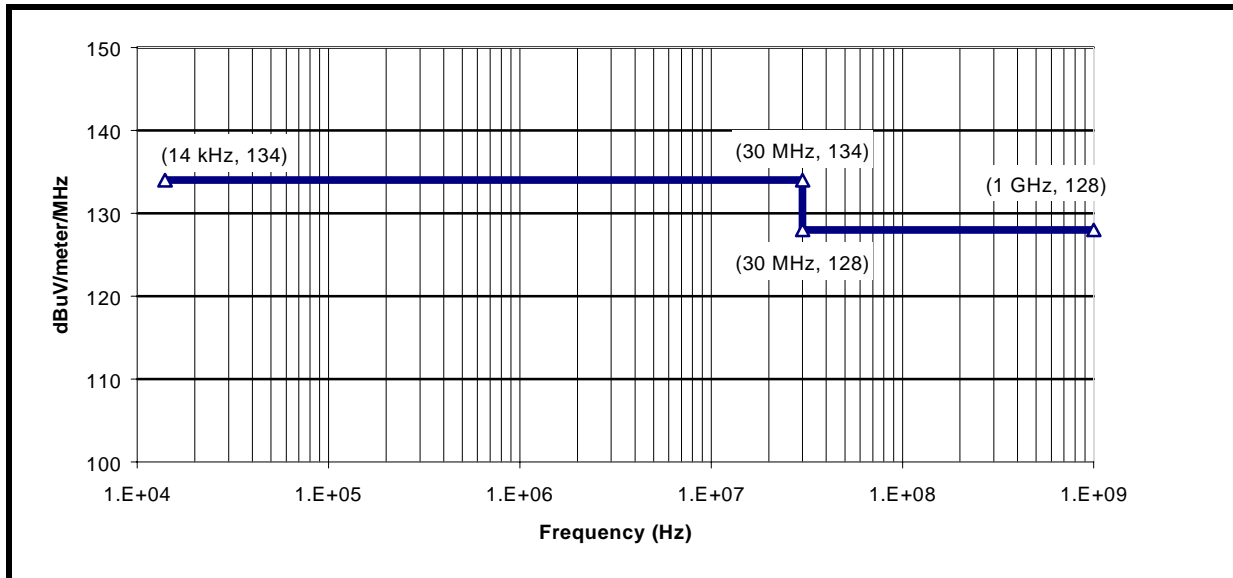


Figure 13 - Maximum Allowable Broadband SV Radiated E-Fields

3.2.6.1.3 LV Radiation Narrowband

The LV narrowband intentional and unintentional radiated emissions at the SIP shall not exceed the maximum allowable emissions curve of Figure 14. Information on the EELV emitters and receivers (power, frequency, E-field levels, and sensitivity of receivers) shall be supplied to the SVC. The levels shown in the figure will be notched at concept-specific frequencies.

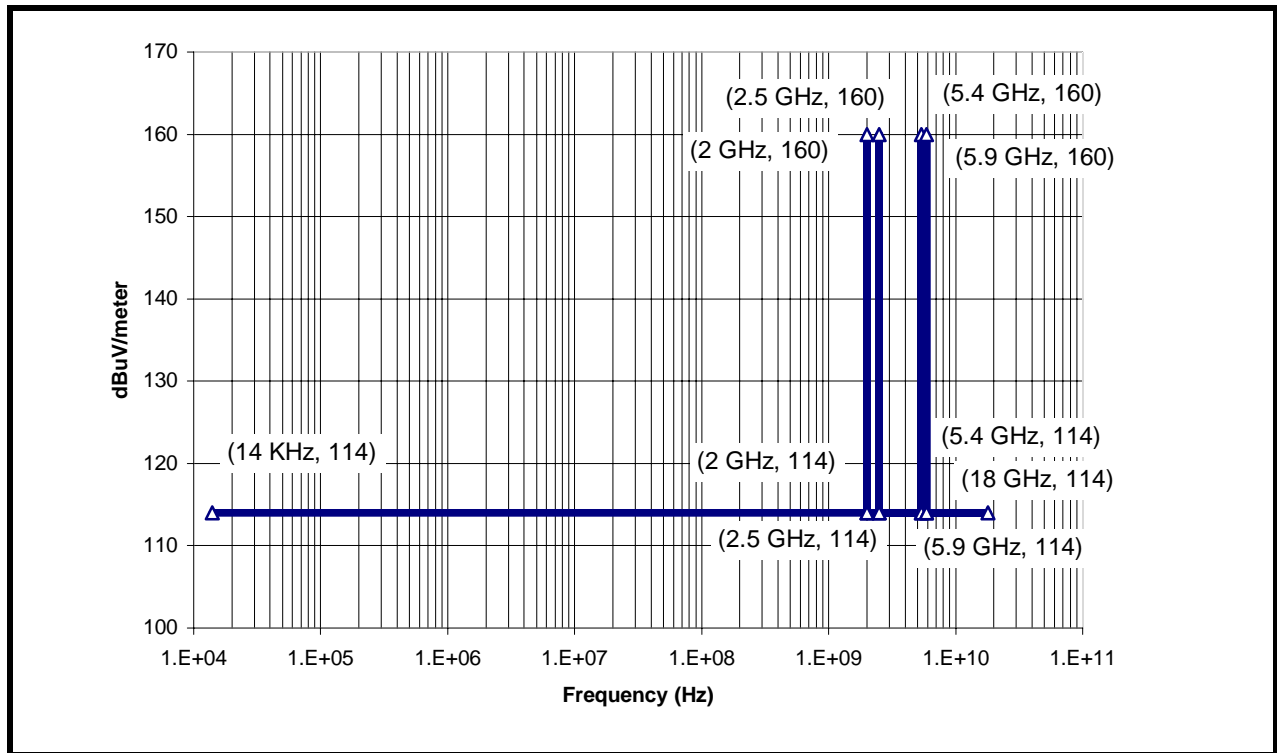


Figure 14- Maximum Allowable Narrowband LV Radiated E-Fields.

3.2.6.1.4 LV Radiation Broadband

The LV unintentional broadband radiated emissions shall not exceed the maximum allowable emissions curve of Figure 15 at the SIP.

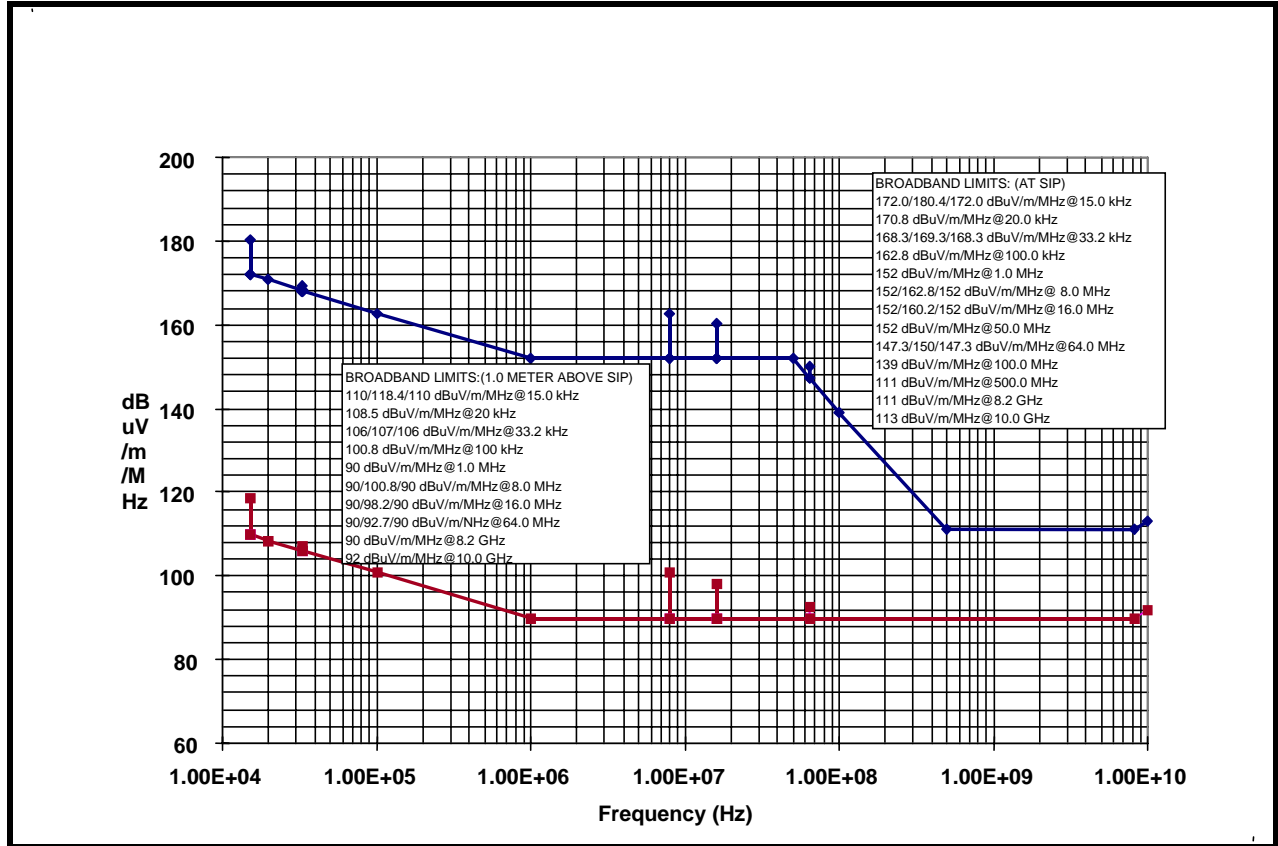


Figure 15- Maximum LV Radiated Broadband Emissions

3.2.6.1.5 Broadband Radiated Emissions Due to Electrostatic Discharge

The LV and payload materials shall be chosen such that the maximum broadband radiated emissions caused by an electrostatic discharge shall not exceed the levels defined in Figure 16 at the SIP.

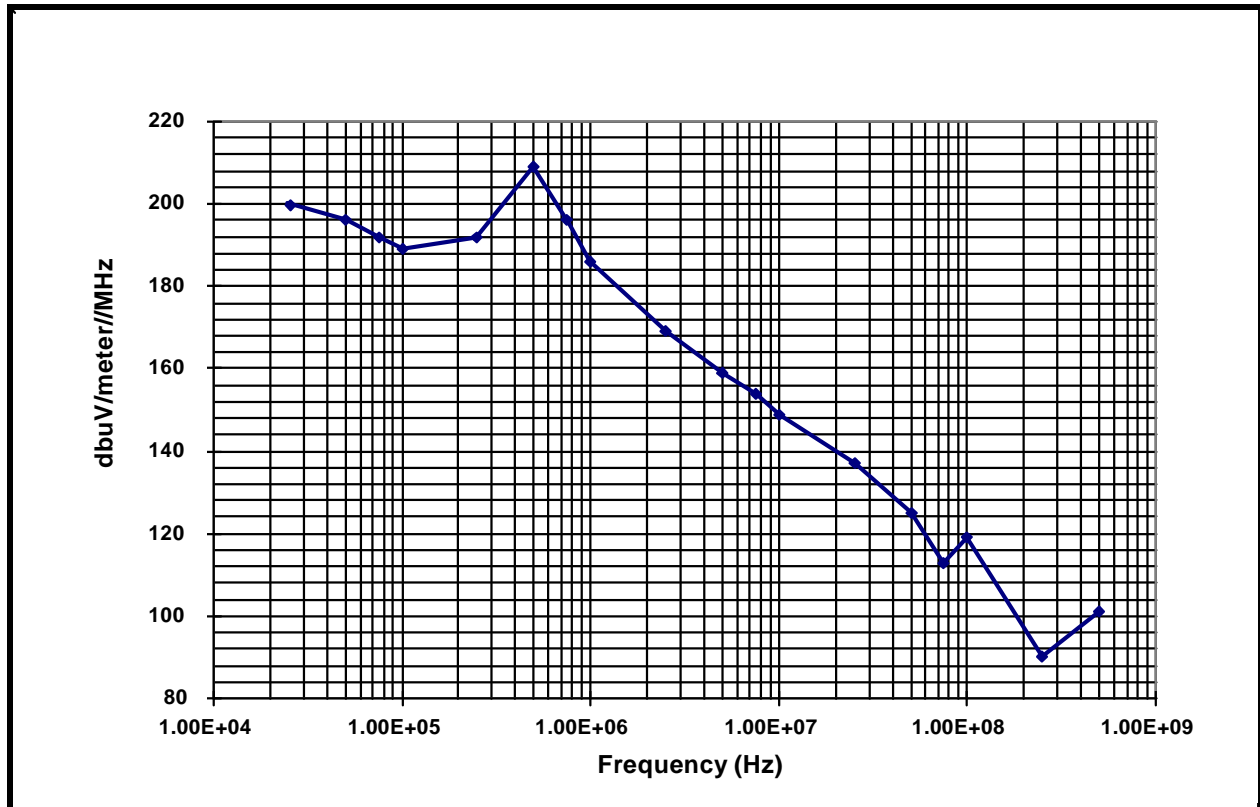


Figure 16- Maximum Allowable Broadband Radiated E-Fields (ESD Source)

3.2.6.1.6 PLF Electrostatic Discharge

Electrostatic charge on the PLF shall not be discharged directly to any portion of the PL surface when the PL-to-PLF distance is equal to, or greater than, the PL/PLF minimum hardware-to-hardware clearance as defined in the LV/PL ICD.

3.2.6.1.7 PLF Broadband E-Field Limits

Maximum electric fields as derived 1 cm from the PLF internal surface shall not exceed the broadband E-field levels stated in Figure 17.

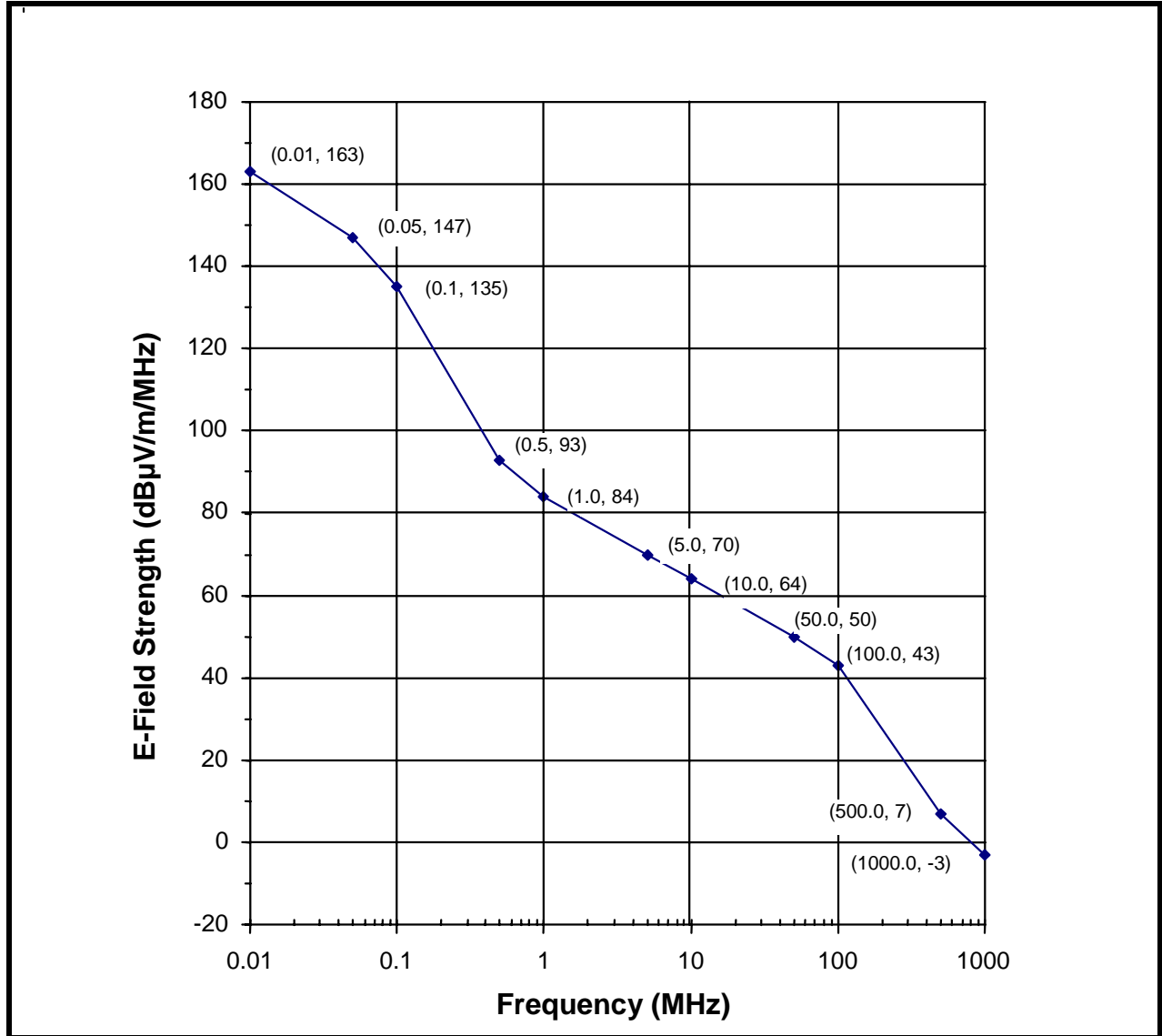


Figure 17 - E-Field Strength Derived Radially 1 cm from PLF Inner Surface

3.2.6.2 Electromagnetic Interference Safety Margin (EMISM)

Electromagnetic Interference Safety Margins (EMISMs) shall be included in the design process to account for variability in system and subsystem components, and for uncertainties involved in verification of system level design requirements. EMISMs of at least 20 dB for Category I interface circuits involving ordnance, and at least 6 dB for Category I non-ordnance and Category II interface circuits are required.

3.2.6.3 Range Compatibility

The flight configured LV/PL shall be compatible with the launch site RF requirements (may include RF mitigation measures coordinated with the launch site). The LVC and SVC shall each be responsible for their individual system compatibility with the worst case theoretical value.

3.2.7 Grounding, Bonding, and Referencing

3.2.7.1 Electrical Bonding

Electrical bonding of mechanical interfaces shall be implemented for management of electrical current paths, for control of voltage potentials to ensure required system performance, and to mitigate personnel hazards. Electrical bonding provisions shall be compatible with corrosion control requirements. The LV/PL interface shall provide a conductive path for electrical bonding of the payload to the launch vehicle. The maximum electrical bonding resistance between the payload and launch vehicle shall be 2.5 milliohms, and shall be verifiable by measurement when they are mated.

3.2.7.2 Interface Connector Bonding

Connector shells shall be electrically bonded to structure. Bonding resistance at these points shall be 2.5 milliohms maximum. The bonding resistance of the cable shield termination path through the mating connector assemblies to the interface shall not exceed 10 milliohms, with no more than 2.5 milliohms across a single joint.

3.2.7.3 Chassis Ground Current

Chassis grounds shall not intentionally be used to conduct power or signal currents.

3.2.7.4 PLF Acoustic and Thermal Blanket Layer Interconnection

Metallized (VDA, VDG, etc.) surfaces and semi-conductive ($\leq 10^9$ ohms per square) layers of thermal (acoustic) insulation blankets shall be designed such that all layers are electrically interconnected. The resistance between any two metallized layers shall be less than or equal to 100 ohms. The resistance between any two semi-conductive layers shall be less than or equal to 10^9 ohms. Existing thermal insulation (acoustic) blanket designs shall be reviewed for acceptance.

3.2.7.5 PLF Acoustic and Thermal Blanket Grounding

Acoustic and thermal insulation blankets shall be connected to the nearest available chassis ground point. The grounding resistance for metallized (VDA, VDG, etc.) layers of the thermal insulated blankets and chassis shall be less than or equal to 100 ohms. The grounding resistance for semi-conductive ($\leq 10^9$ ohms per square) layers of the thermal insulative blankets and chassis shall be less than or equal to 10^9 ohms. There shall be at least one ground point in each square meter of the blanket surface with a minimum of two ground points per blanket. Existing thermal (acoustic) insulation blanket designs shall be reviewed for acceptance.

3.2.8 Separation Ordnance, Power, and Circuits

Separation ordnance power shall be provided by the LV to the primary and redundant PL-provided initiators. Each PL separation ordnance circuit (primary and redundant) shall use separate power sources and separation circuits.

The LV ordnance circuits to the PL shall be isolated from the PL structure by a minimum of 1.0 megohms except for the Electrical Static Discharge (ESD) protective devices.

The firing circuit harnesses shall be shielded to provide a 20 dB minimum margin above the EED's firing threshold, as specified in Section 3.2.6.2.

A total of 16 electro-explosive device (EED) firing circuits, 8 primary and 8 redundant, shall be provided by the LV to the SIP for the SV separation from its adapter. EEDs used will be low voltage, 1 ampere/1 watt/no-fire designs that have an internal bridge wire with a resistance of approximately 1.0 ohm.

Both the primary and the redundant separation ordnance firing signals shall be capable of firing one EED at a time or up to the whole group of 8 at the same time.

The total allowable PL resistance for each EED circuit (i.e., from SIP through PLA to SV and return to SIP including EED resistance) shall be in the range of 0.9 to 2.0 ohms.

Firing signals shall be a single pulse with a duration of 40 ± 10 milliseconds. The firing signal current for each EED circuit shall be at least 5.0 amperes (i.e., a total of 40 amperes minimum if firing 8 at the same time). The firing current shall also be limited at any time to 18 amperes maximum for each EED circuit.

Primary and redundant firings shall be separated at the SVC's discretion by a duration of either less than 5 milliseconds or 80 ± 10 milliseconds of the leading edges of the firing signals as depicted in Figure 18. The SVC will specify the desired firing sequence and firing signal separation choice.

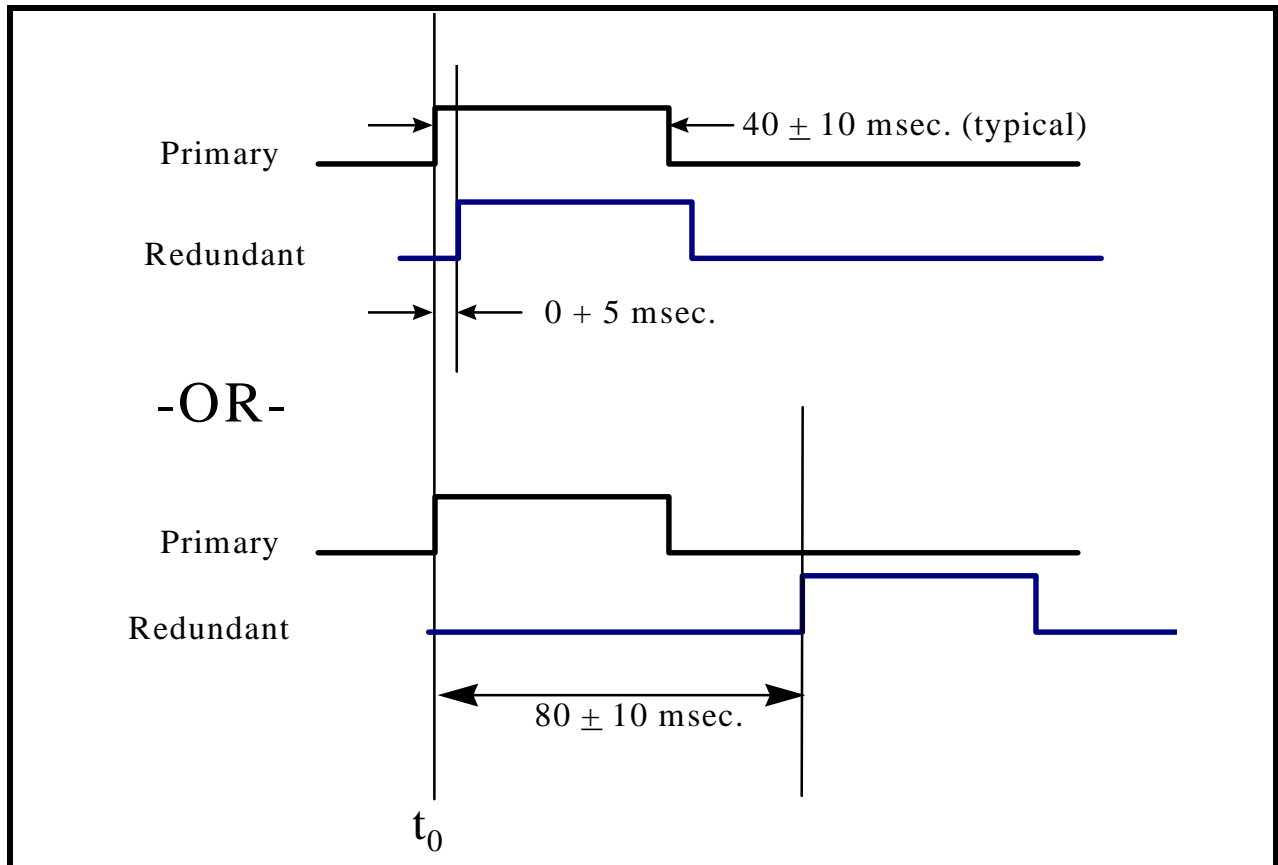


Figure 18 - Ordnance Timing

3.2.8.1 Separation Indication

The SVC shall provide 2 separation breakwires for sense by EELV in separate interface connectors. These shall be isolated from the PL structure by a minimum of 1 megohm. Loopback characteristics of these lines are as follows:

Maximum Resistance: 1.00 ohm
 Minimum Resistance after break: 1 Megohm

3.3 Fluid Interfaces and Services

The LVC shall provide support for fluid services as specified in the following paragraphs. There are no provisions for fueling SVs at LV facilities (including the launch pad) as a standard service. Considerations for SV detanking are covered in Section 4.5.

3.3.1 Coolant

No cooling fluids other than gaseous nitrogen (mission-unique) or air are provided to the PL. These are discussed in Section 3.3.2 below. Liquid cooling fluids may be provided on a mission-unique basis.

3.3.2 Air Conditioning

3.3.2.1 Payload Compartment Air Characteristics and Flow

The LVC shall provide an air conditioning duct located at the top of the standard payload envelope cylinder, directed not to impinge directly on the payload. The standard duct is switchable to provide air or nitrogen (mission-unique) flow from a redundant source as determined by the LVC and as specified below. In addition, the launch pad air conditioning provisions shall not preclude the routing of a fly-off umbilical fitting located at the base of the payload fairing in addition to the standard duct near the top of the fairing.

Air conditioning will be available from payload encapsulation through lift-off with periods of interruption as negotiated in the LV/PL ICD.

3.3.2.1.1 Transport and Hoist

The LVC shall ensure that the payload compartment meets contamination control limits during transport and hoist as specified in Section 3.5 or as negotiated in the LV/PL ICD. The LVC standard services shall maintain the relative humidity at 50% or below and the temperature inside the PLF within the range of 65 and 85 degrees F during all phases of transport and hoist. The LVC shall provide a gaseous nitrogen instrument purge as a mission-unique service. Air flow during hoist, if needed and specified in the LV/PL ICD, is a mission-unique service.

3.3.2.1.2 Air Flow Following Payload Mate to the LV

Air: Airflow shall be provided by the LVC with the following characteristics:

Inlet temperature and relative humidity: 50-85°F (controllable to $\pm 5^\circ$ F) with 20-50% relative humidity
and
50-70°F (controllable to $\pm 5^\circ$ F) with 35-50% relative humidity when required for sensitive operations

Inlet cleanliness: Class 5000 guaranteed (HEPA filters not DOP tested)

Inlet mass flow rates (air):

5m PLF: 200-300 lb./min. (controllable to ± 12.5 lb/min.)

4m PLF: 80-160 lb./min. (controllable to ± 5 lb/min. after start-up period)

Flow velocity: The payload air distribution system shall provide a maximum airflow velocity less than 32 fps for the 4m PLF in all directions and 35 fps for the 5m PLF in all directions. There will be localized areas of higher flow velocity at, near, or associated with the air conditioning duct outlet. Maximum airflow velocities correspond to maximum inlet mass flow rates. Reduced flow velocities are achievable at lower inlet mass flow rates.

The LVC shall provide for the capability to divert up to 40% of the airflow to the aft portion of the payload envelope.

N₂: Purge of the entire PLF with GN₂ prior to launch is not a standard payload service. This type of purge is considered a mission-unique service.

3.3.3 SV Instrument Purge (GN₂)

The LV integration facility shall have provisions for either Grade B or high purity Grade C GN₂, as specified in the LV/PL ICD, to supply purges for individual payload instruments. (Nitrogen grades are defined in Section 1.5.) The characteristics of this GN₂ are as follows:

Inlet dewpoint: Maximum of -35 ° F

Inlet cleanliness: Class 5000 guaranteed (HEPA filters not DOP tested)

Flow rate: 0-500 standard cubic feet per hour (SCFH)

This provision shall not preclude SVC-provided carts from being used for higher purity or higher flow rate payload instrument purges.

3.3.4 GHe

There is no provision for providing gaseous Helium to the payload.

3.4 Thermal Environments

3.4.1 Payload Compartment Thermal Environment

The worst case thermal environment inside the PLF during ascent is depicted Figure 19. The surfaces seen by the PL will generally fall into one of two categories: surfaces with low emissivity ($e \leq 0.3$) and those of higher emissivity ($e \leq 0.9$). Maximum temperatures as a function of the time from launch, 300°F for a surface emissivity of 0.3 and 200° for a surface emissivity of 0.9, are shown in the plot. The exact configuration and percentages of each type of surface is both mission-specific and LV concept specific. Temperatures may exceed those shown but in no case shall the total integrated thermal energy imparted to the PL exceed the maximum total integrated energy indicated by the temperature profile shown in Figure 19.

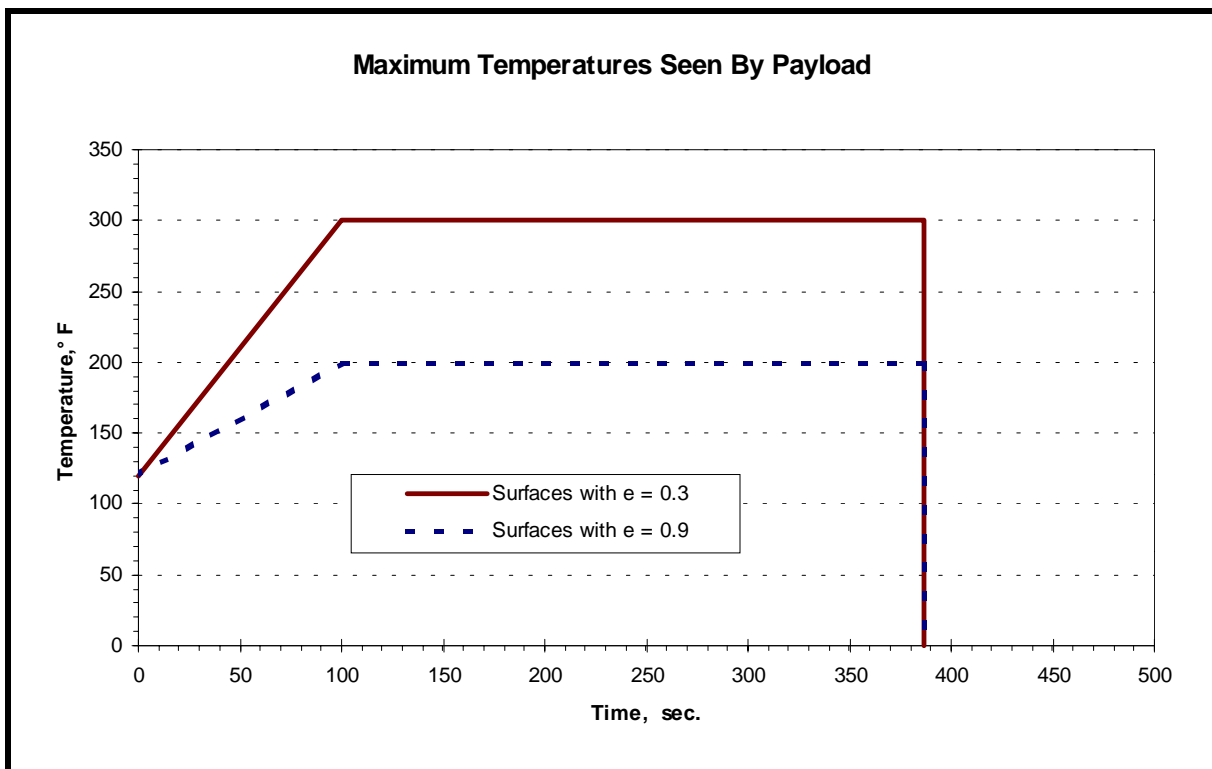


Figure 19 - Maximum PLF Inner Surface Temperatures

3.4.2 Free Molecular Heating

The maximum instantaneous 3-sigma Free Molecular Heating (FMH) rate on PL surfaces perpendicular to the velocity vector at the time of fairing separation shall not exceed 320 Btu/hr/ft². Lower or higher values may be achieved with impact on LV performance and will be addressed on a case-by-case basis.

3.5 Contamination Control

3.5.1 Cleanliness

Exposed LV surfaces and ground support equipment to be inserted within the payload fairing shall be cleaned and inspected to be free of visible particles with the unaided eye (except for vision corrected to 20/20), with a 100-125 ft-candle light at a distance of 6 to 18 inches. Non-volatile residue left on the above surfaces shall not exceed 1.0 mg/ft².

All payloads that have a specific contamination requirement shall, at the time of payload mating, demonstrate a state of cleanliness that is consistent with their contamination requirement.

3.5.2 Impingement

LV plume impingement shall be controlled in accordance with the requirements specified in the LV/PL ICD.

3.5.3 Windborne Contamination

The LVC shall provide protection to the payload from windborne contamination and maintain the cleanliness levels of section 3.5.1 from payload encapsulation through lift-off.

3.5.4 Flight Contamination

3.5.4.1 Particulate

Particulate contamination levels from the LV shall not exceed 1% surface obscuration from payload encapsulation through CCAM.

3.5.4.2 Molecular

Molecular contamination levels from the LV shall not exceed 150 angstroms from payload encapsulation through CCAM.

3.5.5 Material Selection

3.5.5.1 Non-Metallic Materials

Selection of nonmetallic materials shall include consideration of wear products, shedding and flaking properties, as required, to ensure that the particulate contamination of the PL by the LV shall not exceed the requirements of Section 3.5.4.1 during processing, launch, and ascent. In addition to the requirements of Section 3.5.4.2, the nonmetallic materials within the PLF volume exposed to thermal vacuum shall not exceed a total mass loss of less than or equal to 1.0% and volatile condensable matter less than or equal to 0.1% when tested per ASTM E-595 or equivalent method. Exceptions for usage on the flight vehicle are below.

Final acceptance of nonmetallic materials shall be determined by analysis of the material outgassing and deposition characteristics. If materials needed for specific applications or used in existing design do not meet these requirements, but the sum total determined by analysis meets the flight contamination requirements, a material usage agreement, including rationale for use of the materials, shall be issued by the cognizant Parts Materials and Processes (PMP) engineer and provided upon request to the Air Force, SVC or Launch System Integration Contractor (LSIC). Specific criteria for material selection may be dependent upon payload unique requirements. The list for each material requesting a materials usage agreement shall include the following:

1. Manufacturer's trade name of the product or material
2. Manufacturer of the material
3. Thermal and vacuum stability data
4. Rationale for use of non-approved materials including the mass, surface area and location of the material used
5. Contribution of the total outgassing/deposition environment

3.5.5.2 Metallic Materials

The selection of metallic materials shall include consideration of corrosion, wear products shedding and flaking in order to reduce particulate contamination. Dissimilar metals in contact shall be avoided unless adequately protected against galvanic corrosion.

Mercury, compounds containing mercury, zinc plating, cadmium parts and cadmium-plated parts shall not be used on flight or LV ground support equipment that comes into direct contact with PL flight hardware.

Pure tin or tin electroplate shall not be used except when re-fused, re-flowed, or alloyed with lead, antimony or bismuth.

3.6 Acceleration Load Factors

Figure 20, Figure 21, and Figure 22 define PL center-of-gravity acceleration values that, when used to calculate LV/PL interface bending moments, axial loads, and shear loads, will yield maximum loads imposed by the LV on the PL **at the SIP**. For PL weights other than those given in these figures, adjustments to the axial accelerations should be made according to steady state acceleration vs. weight curves, which are concept-specific. For payloads weighing less than those indicated in the figures, lateral accelerations may be higher. Contact the EELV SPO for appropriate design loads factors.

These load factors presented in Figure 20, Figure 21, and Figure 22 are not intended for the design of PL structures. Load factors for the preliminary design of the PL structure should be derived for each PL by taking into account the unique design features of the PL and its interaction with the launch vehicle. These factors are to be no less than the values in Figure 20, Figure 21, and Figure 22 (properly adjusted for PL weight). Following the preliminary design, definition of PL structural loads will be accomplished by means of an early dynamic coupled loads analysis.

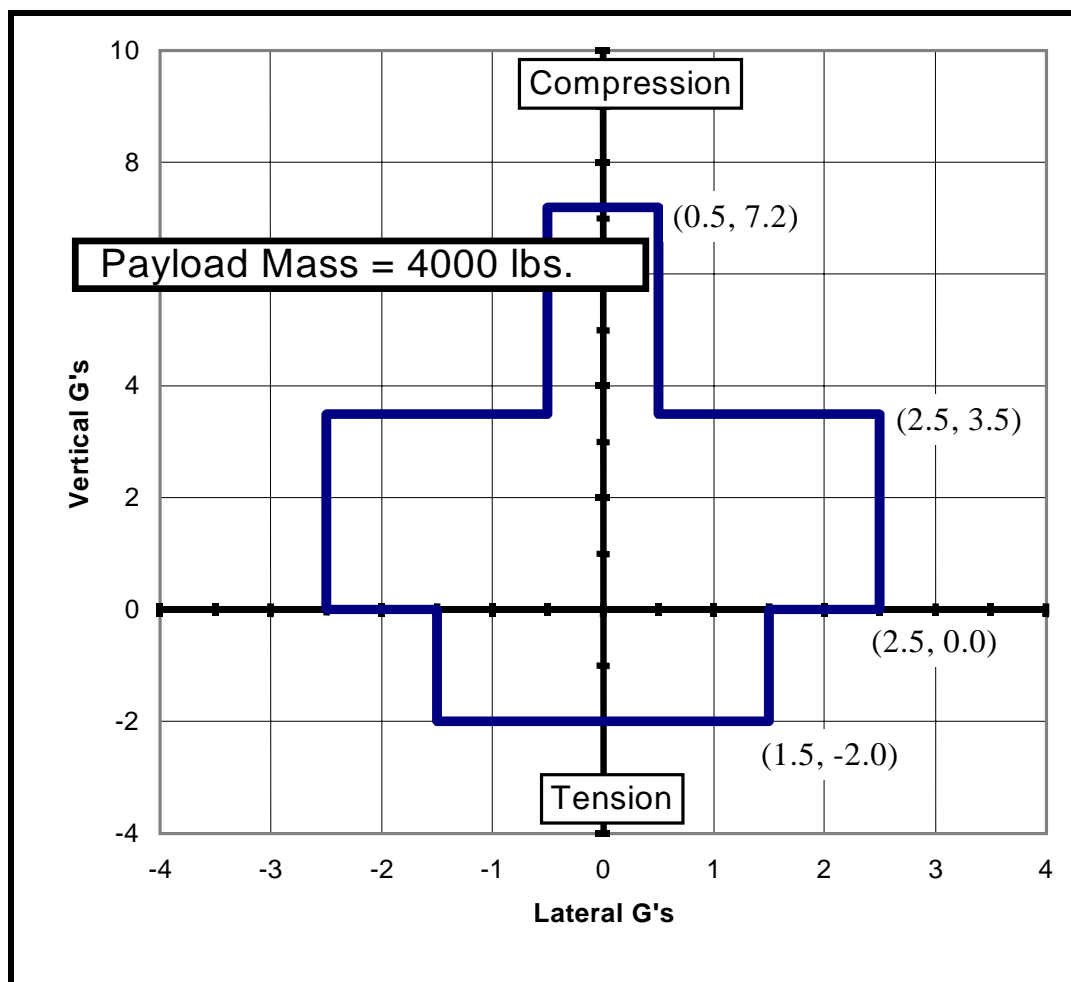


Figure 20 - MPC-S Quasi-Static Load Factors

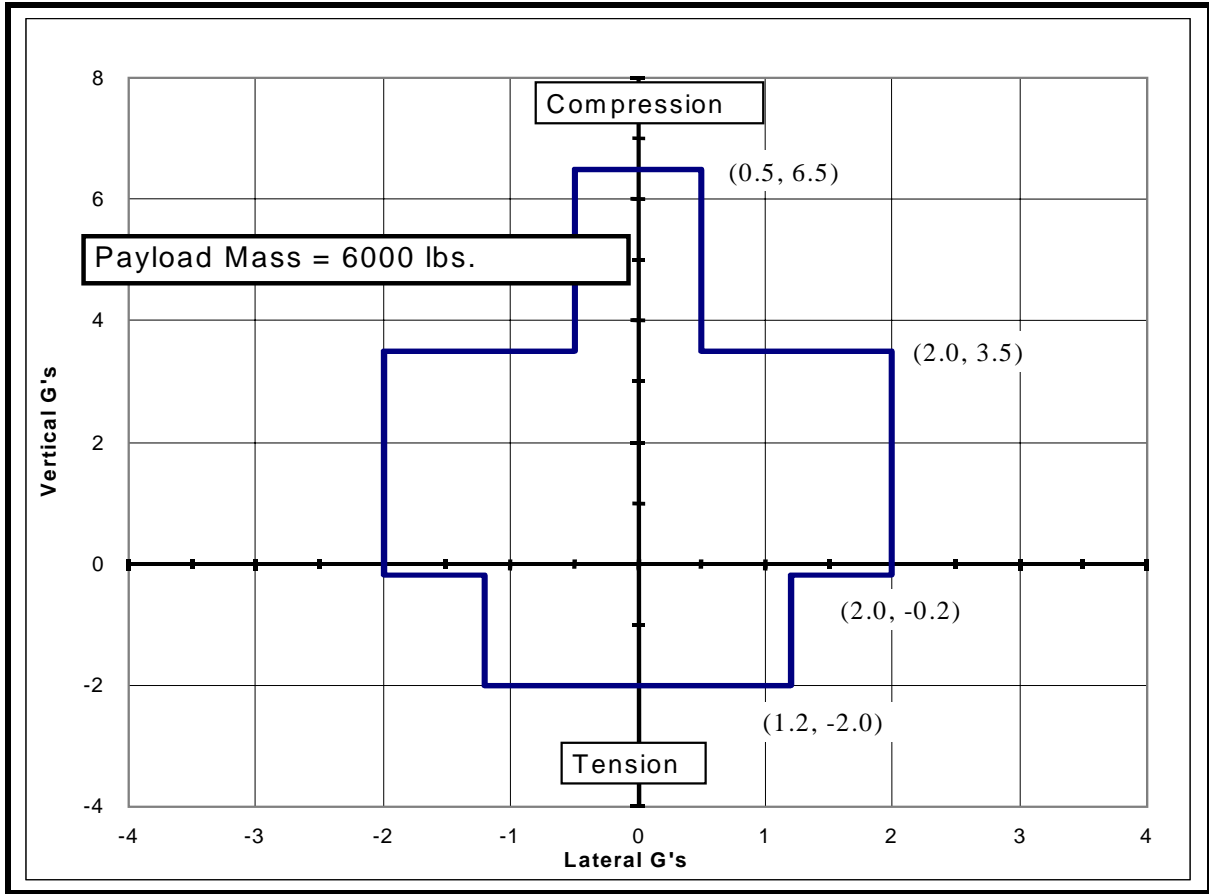


Figure 21 – 4m IPC and MPC Quasi-Static Load Factors

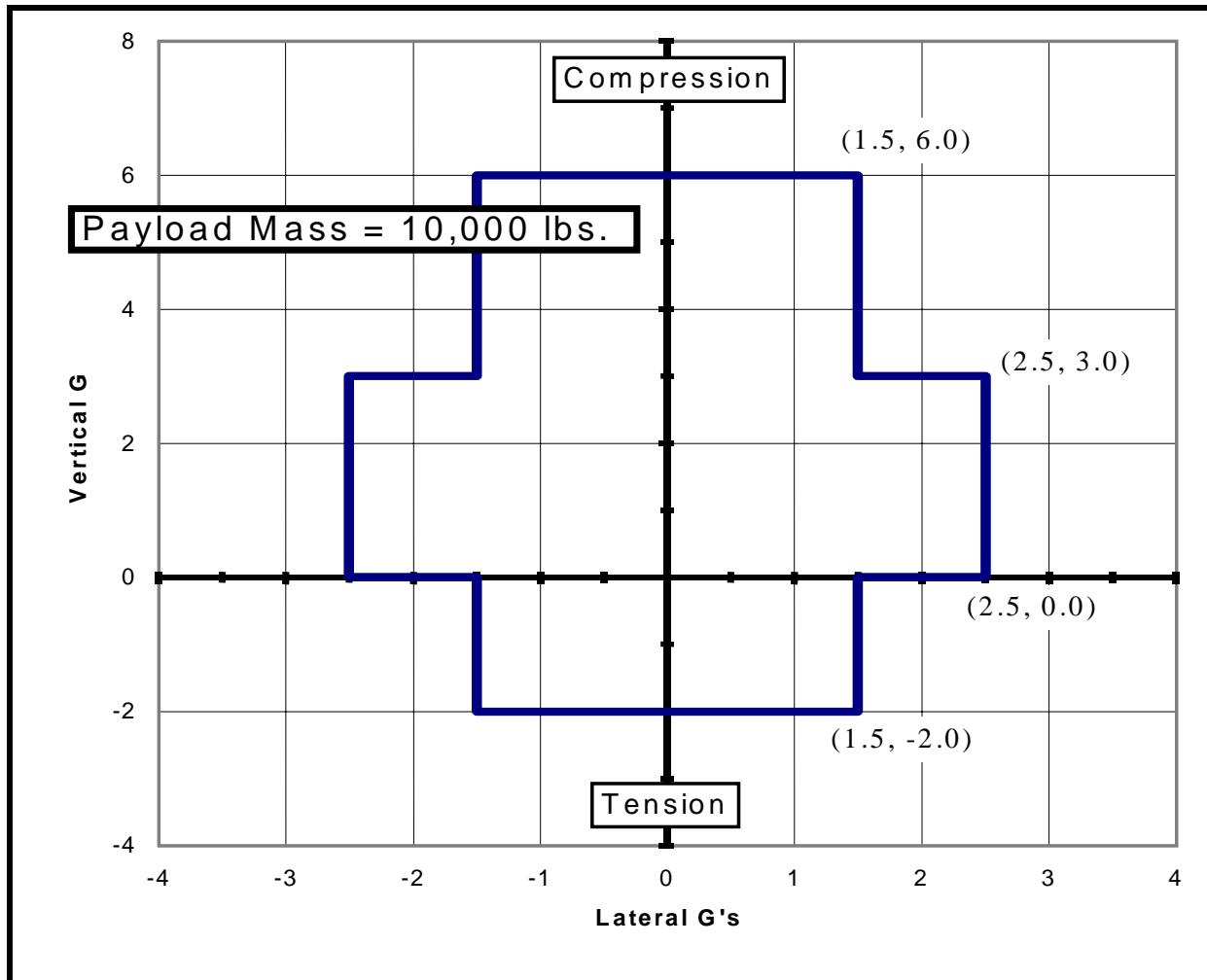


Figure 22 - 5m IPC and HPC Quasi-Static Load Factors

3.7 Vibration

The maximum in-flight vibration levels will be provided in the LV/PL ICD, but are not defined in this standard. PL design for vibration should be performed using acoustic data provided in the next section.

3.8 Acoustics

The PL maximum predicted sound pressure levels (SPL) (value at 95th percentile with a 50% confidence) from liftoff through SV deployment shall not exceed the values provided in Table 3. The acoustic levels are plotted in Figure 23, Figure 24 and Figure 25 as one-third octave band sound pressure levels versus one-third octave band center frequency for MPC, 4m IPC, and 5m IPC/HPC, respectively. The values shown are for a typical payload with an equivalent cross-section area fill of 60 percent. The defined payload dynamic envelopes (refer to Section 3.1.3) were used to calculate the 60 percent cross-section area fill. The provided acoustics levels have been adjusted to represent the equivalent sound pressure levels consistent with the standard acoustic test practice of locating control microphones 508 mm (20 inches) from the PL surface. Payloads with a larger cross-sectional area than 60 percent will incur higher acoustic levels.

1/3 Octave Band Center Frequency (Hz)	MPC PL Sound Pressure Level (dB re 20 micropascal)	4m IPC PL Sound Pressure Level (dB re 20 micropascal)	5m IPC/HPC PL Sound Pressure Level (dB re 20 micropascal)
32	118.0	122.0	129.0
40	123.4	123.7	130.5
50	123.0	125.2	131.0
63	124.5	126.3	132.0
80	126.0	128.0	132.5
100	128.2	131.0	133.0
125	129.1	132.2	133.0
160	130.0	133.4	132.7
200	131.1	131.9	131.8
250	130.5	130.5	131.0
315	130.0	130.0	130.2
400	130.0	130.0	128.8
500	129.8	129.8	127.5
630	128.3	128.3	126.2
800	126.9	126.9	124.3
1000	123.9	123.9	122.5
1250	122.0	122.0	120.7
1600	120.4	120.4	118.3
2000	120.9	120.9	116.5
2500	117.9	117.9	115.0
3150	117.2	117.2	113.0
4000	115.5	115.5	111.5
5000	114.5	114.5	109.5
6300	113.7	113.7	107.5
8000	113.9	113.9	106.0
10000	114.8	114.8	104.0
OASPL	140.4	141.6	142.7

Table 3 - PL Maximum Acoustic Levels

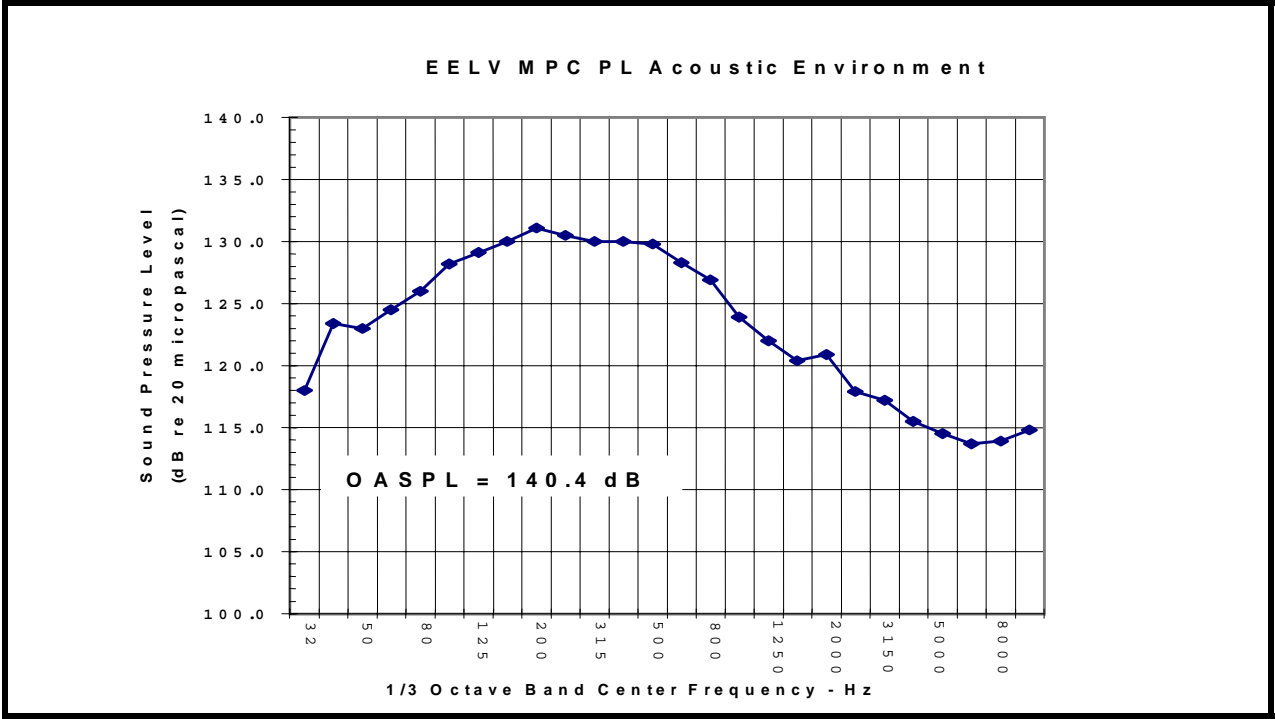


Figure 23 – MPC Acoustic Levels

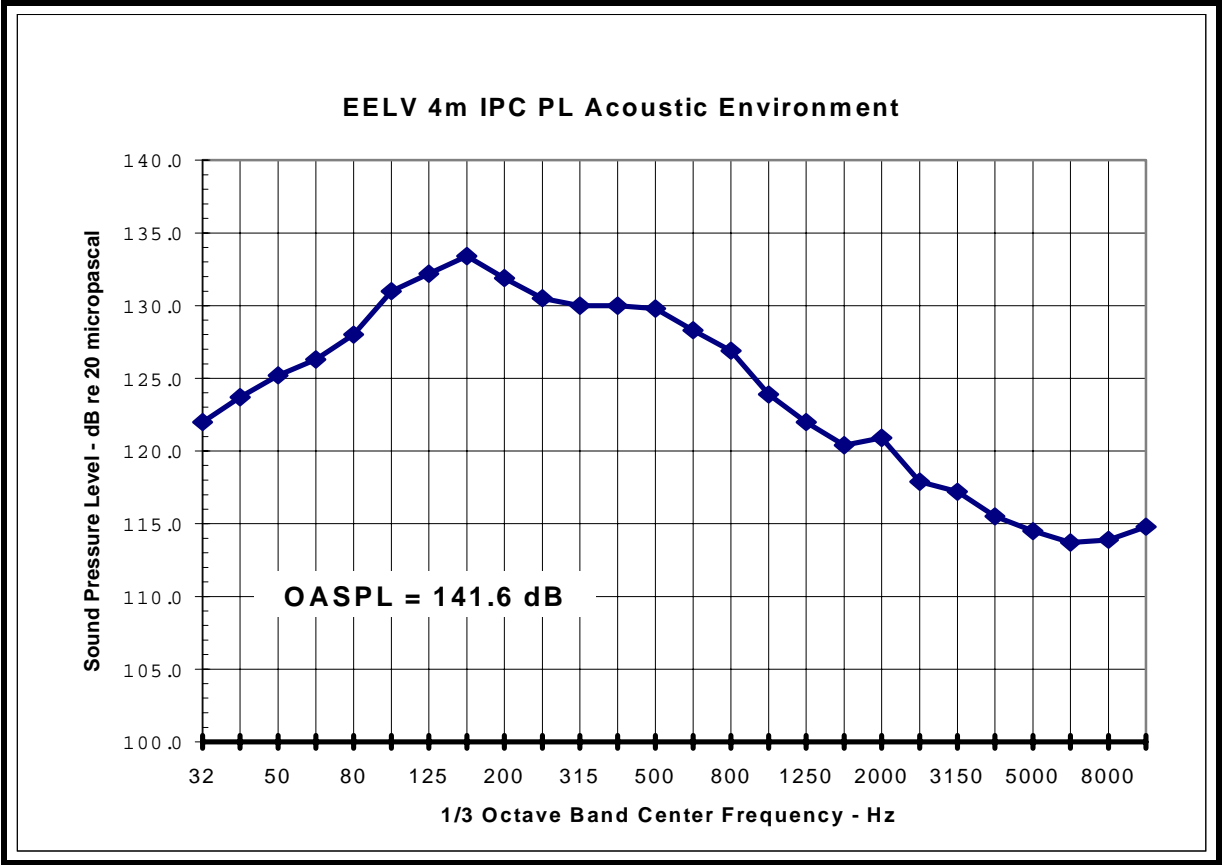


Figure 24 – 4m IPC Acoustic Levels

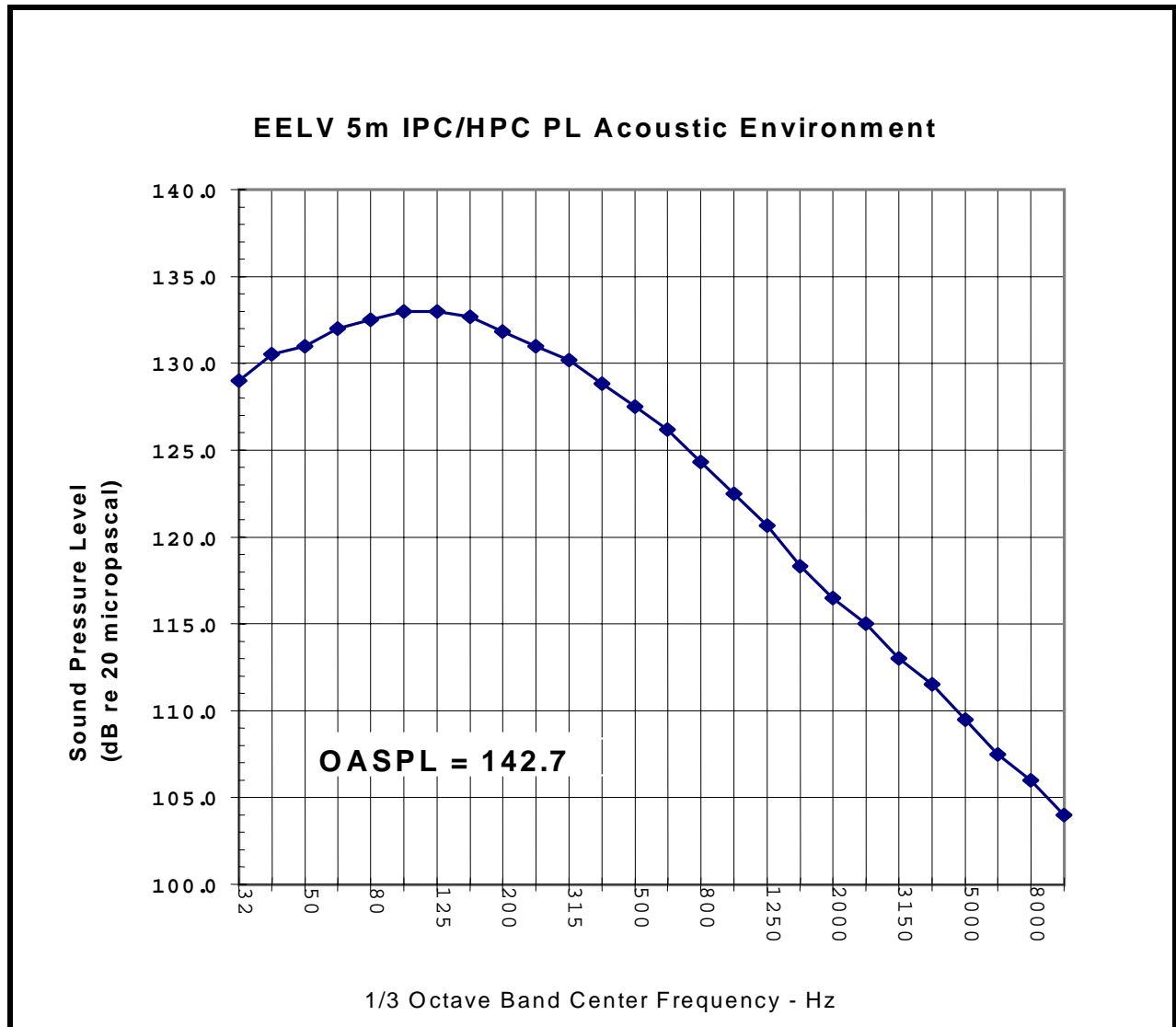


Figure 25 – 5m IPC/HPC Acoustic Levels

3.9 Shock

The maximum shock spectrum at the SIP (value at 95% probability with 50% confidence; resonant amplification factor, $Q=10$) shall not exceed the levels shown in Table 4. These levels are shown graphically in Figure 26.

Shock Spectrum from EELV to PL (G's)				Shock Spectrum from PL to EELV Interface (G's) (due to SV separation)	
Freq-Hz	HPC	5m IPC	4m IPC/MPC	Freq-Hz	All Payload Classes
100	70	70	40	100	150
125	-	-	-	125	175
160	-	-	-	160	220
200	80	-	-	200	260
250	-	-	-	250	320
315	-	-	-	315	400
400	-	-	-	400	500
500	-	-	-	500	725
630	-	-	-	630	1100
800	-	-	-	800	2000
1600	-	-	-	1600	5000
2000	3000	3000	-	2000	5000
5000	3000	3000	3000	5000	5000
10000	3000	3000	3000	10000	5000

Refer to graph of Figure 26 for intermediate frequencies

Table 4 - EELV Maximum Shock Levels

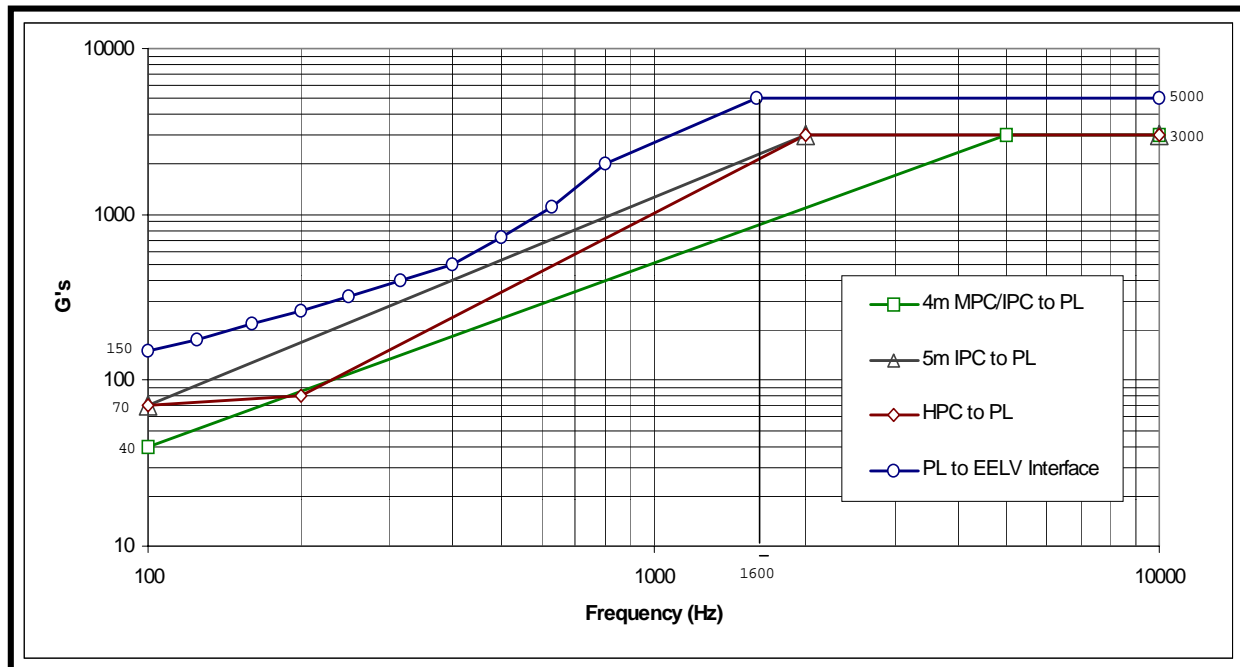


Figure 26- EELV Maximum Shock Levels

3.10 Ground Processing Load Factors

Ground processing load factors will be provided in the LV/PL ICD. They will be less than the flight load factors shown in Section 3.6.

3.11 Payload Fairing Internal Pressure

Payload fairing internal pressure decay rates for HPC shall be limited to 0.4 psi/sec except for a brief transonic spike to 0.6 psi/sec. Decay rates for IPC shall be limited to 0.4 psi/sec except for a brief transonic spike to 0.9 psi/sec. Decay rates for MPC shall be limited to 0.3 psi/sec except for a brief transonic spike to 0.9 psi/sec.

4. FACILITIES AND PROCESSING

4.1 Propellant Services

The PL shall complete propellant loading prior to encapsulation within the EELV payload fairing.

4.2 Access to Payloads - Timelines

Final physical access to the PL will occur no later than 24 hours prior to launch. Exact timelines are concept-specific.

4.3 Payload Battery Charging

4.3.1 Full Power Charging

The LVC shall accommodate PL pre-launch battery charging from drained state to full charge state via the T-0 umbilical or via drag-on electrical cables at the appropriate platform level. Ground power shall be in accordance with the requirements of Section 3.2.4. The timing for providing this service will be negotiated in the LV/PL ICD.

4.3.2 Trickle Charging

The LVC shall accommodate PL battery trickle charging to maintain battery charge via the T-0 umbilical power lines. Ground power shall be in accordance with the requirements of Section 3.2.4.

4.4 Hazardous Payload Processing

PL hazardous processing, except for tasks which may not be carried out until just prior to movement of the LV to the launch pad (e.g., arming of ordnance), shall be completed prior to final close-out of the EELV payload fairing.

4.5 Detanking

If it is required that the PL have the capability for emergency de-tanking at the launch complex, the PL shall use manually connected/disconnected interfaces accessible (as provided in Section 3.1.4.2) without personnel entry into the fairing. Tank drain, vent, purge, and pressurization (if required) shall be a payload responsibility and shall be accomplished through a SVC-provided propellant servicing unit.

The LVC shall provide measures for personnel protection, collection of hazardous fuels, and storage or disposal of collected fuels. The SVC shall provide certified containers for any detanked commodity that will be stored.

4.6 Lightning Protection

Lightning protection shall be provided by the LVC in accordance with EWR 127-1 Chapter 5. PL electrical circuits shall be designed to minimize damage due to lightning strikes.